UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

November 16, 2005

MEMORANDUM

SUBJECT: Review of *"Evaluation of Post-Application Exposures to Sodium o-Phenylphenate Tetrahydrate/o-Phenylphenol to Workers During Post-Harvest Activities at Pear and Citrus Fruit Packaging Facilities"*

FROM: Matthew Crowley, Environmental Protection Specialist
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DP Barcode: D209211

PC Code(s): 064103 – o-Phenylphenol
064104 – o-Phenylphenol, sodium salt

EPA MRID No.: 43432901

The following is a secondary review and discussion of a Versar, Inc. report on the 1994 Dow Chemical Company submission, "Evaluation of Post-Application Exposures to Sodium o-Phenylphenate Tetrahydrate/o-Phenylphenol to Workers During Post-Harvest Activities at Pear and Citrus Fruit Packaging Facilities." The study was conducted under U.S. EPA OPPTS Test Guidelines Series 875, Occupational and Residential Exposure Test Guidelines, Group A: 875.1200 (dermal exposure) and 875.1400 (inhalation exposure).

This secondary review is an overview and discussion of the study and reflects current Health Effects Division (HED) standard operating procedures. For more specific details of the study Versar, Inc.'s primary review is attached (Attachment 1).

Executive Summary

Despite issues of concern and indeterminable effects of variables described in this review, the results of this study represent the best available data to determine dermal and inhalation exposures for workers (sorters and packers) in citrus fruits and pear packaging facilities to o-Phenylphenol (OPP) and o-Phenylphenol, sodium salt (SOPP). This review presents a summary and discussion of the results presented in both the registrant's submission and Versar Inc.'s review. Normality testing was inconclusive; therefore, both geometric and arithmetic means are presented.

Study Overview

This study was conducted to determine postapplication dermal and inhalation exposures to workers (sorters and packers) following the application of SOPP/OPP solutions to citrus fruits and pears. At each of 6 facilities (3 pear and 3 citrus), located in Washington, Florida, and California, a complete set of monitoring samples for dermal and inhalation exposure was collected from 5 sorters and 5 packers totaling 60 participants (2 participants had incomplete data sets). Area air monitoring was also conducted in the three citrus facilities.

All application solutions were prepared using SOPP formulations; however, different concentrations (i.e., application rates) were used in each facility. Samples of treatment solutions were analyzed at each facility and showed a range of 0.140 to 1.29% (averages, expressed as % OPP by weight).

After treatment (by automated dip, foam, or spray) the citrus or pears were conveyed to a pre-sort station where workers would pull out culls (i.e., damaged fruit). It should be noted that only workers performing pre-sorting activities for citrus fruits were monitored. Fruits finally reached the sorters and packers after being cleaned, waxed, and dried.

Sorters separated the citrus/pears into different grades based on appearance, quality, and size. Packers in the pear facilities performed all activities (i.e., wrapping, boxing) manually, while packers in two citrus facilities operated packing machines and performed manual work. Approximately 180-300 boxes (40-50 pounds per box) of pears are packaged per day. Similar information was not provided for citrus packers.

Study Results

Tables 1 – 3 summarize exposure results from both the data presented in the Study (i.e., the registrant's submission) and Versar, Inc.'s review. Results from both parties are presented for comparison in analysis methodologies. Versar, Inc. reported that normality testing was inconclusive (see Attachment 1); therefore both the arithmetic and geometric means are presented. Differences in results between the Study and Versar Inc.'s review are discussed in brief as well as any errors in the data.

Table 1: Area Monitoring in Citrus Facilities				
Facility #	Concentration (ug/m^3)			
	Arithmetic Mean		Geometric Mean	
	Study	Versar Review	Study	Versar Review
4	23.1	22.7	17.5	13.8
5	11.8	11.5	3.3	2.9
6	90.3	90.1	47.2	46.9
All	38.6	38.3	14.6	13.8

- Results are presented in ug/m^3 for comparison purposes. Versar, Inc. additionally presented results in mg/workday and mg/hour using the NAFTA breathing rate of 16.7 L/min for "light" activities.
- Differences in results are due to field fortification corrections. The Study results are corrected for field fortifications less than 100%. As stated in OPPTS guidelines, Versar, Inc. corrected only those results with field fortifications below 90%.

Table 2: Dermal Exposure Results for Sorters and Packers in Citrus Fruit and Pear Facilities						
Facilities (State)	Crop	Activity	Dermal Exposure (ug/workday)			
			Arithmetic Mean		Geometric Mean	
			Study	Versar Review	Study	Versar Review
1, 2, 3 (WA)	Pears	Sorter	6134	6023	5368	5207
		Packer	4025	3901	3871	3751
4 (FL)	Citrus	Sorter	2453	2444	2365	2356
		Pre-sorter	7873	7850	6224	6201
		Packer	1500	1498	1336	1334
5, 6 (CA)	Citrus	Sorter	1934	1934	1194	1192
		Pre-sorter	4513	4512	3696	3692
		Packer	725	725	562	561

- Differences in results are due to field fortification corrections. The Study results are corrected for field fortifications less than 100%. As stated in OPPTS guidelines, Versar, Inc. corrected only those results with field fortifications below 90%.
- The Study incorrectly reported the corrected T-shirt exposure for Packer #15 (Pear Facility #3) as 827 ug; the correct value was 872 ug. Table 2 calculations reflect this correction.
- The Study incorrectly reported the limit of detection (LOD) for corrected T-shirt exposures for Packer #s 22-26 (Citrus Facility #5) as 48.3 ug; the correct LOD was 67.6 ug. Table 2 calculations reflect this correction.
- The Study reported an incorrect handrinse summation for Sorter #21 (i.e., total daily hand exposure) as 2568 ug; the correct sum was 2546. Table 2 calculations reflect this correction.
- Neither the Study nor Versar, Inc. separated pre-sorters from the sorter data in their results. This was done for the purposes of this secondary review.
- Results are shown in terms of mg/workday for comparison purposes. Versar, Inc. additionally presented results in mg/hour.

Table 3: Inhalation Exposure Results for Sorters and Packers in Citrus Fruit and Pear Facilities						
Facilities (State)	Crop	Activity	Inhalation Exposure (ug/m^3)			
			Arithmetic Mean		Geometric Mean	
			Study	Versar Review	Study	Versar Review
1, 2, 3 (WA)	Pears	Sorter	95.1	95.1	89.2	89.2
		Packer	75.4	75.4	74.2	74.2
4 (FL)	Citrus	Sorter	19.8	19.5	18.7	18.4
		Pre-sorter	43.7	42.8	43.2	42.4
		Packer	4.6	4.5	4.5	4.4
5, 6 (CA)	Citrus	Sorter	7.6	7.6	3.2	3.1
		Pre-sorter	93.2	92.7	64.5	63.7
		Packer	6.8	6.7	3.3	3.3

- Results are presented in ug/m^3 for comparison purposes. Versar, Inc. additionally presented results in mg/workday and mg/hour using the NAFTA breathing rate of 16.7 L/min for "light" activities.
- Differences in results are due to field fortification corrections. The Study results are corrected for field fortifications less than 100%. As stated in OPPTS guidelines, Versar, Inc. corrected only those results with field fortifications below 90%.
- Neither the Study nor Versar, Inc. separated pre-sorters from the sorter data in their results. This was done for the purposes of this secondary review.

Discussion

Issues of Concern and Study Variables

Major issues of concern identified by Versar, Inc. include:

- Potential dermal exposure was not monitored for the lower body and face/neck areas.
- Exposure to the hands was monitored by collection of hand rinse samples. Some of the workers wore thin cotton gloves in order to protect their hands from cuts and also to protect the fruit during post-application handling. Residue already present on the gloves or residue from the post-harvest fruit handling by participants in this Study remaining on these gloves was not considered in this Study. Gloves worn by some of the workers were not pre-washed and had been used in previous fruit handling events. The gloves may have contained dried SOPP/OPP residue. Also some of the residue present on fruit handled during this sampling event may have remained on the gloves and not transferred to the hand of the workers. Consequently, hand exposures may be over- or under-estimated by use of this sampling protocol.
- At each citrus facility, two of the five citrus sorters were monitored at the pre-sorting area while the remaining three citrus sorters were monitored at the main sorting area. The pre-sorters handled fruit immediately after SOPP treatment and the main sorters handled fruit further along in the packaging process. Pre-sorters were not monitored at the pear facilities.
- The test substances used were not identified and labels were not provided in the Study Report. Therefore, it could not be determined if the maximum application rate was used and if the product was used according to label directions.

Study variables identified by Versar, Inc. include:

- Fruit type – citrus and pears;
- Formulation types;
- Fruit treatment method (dip, spray, foam);
- Fruit coating (wax layer versus no overcoat);
- Worker proximity to the treatment area;
- Time worker spends in facility (less than 8 hours up to 12 hours);
- Facility size and ventilation equipment;
- Concentration of SOPP in treatment solution;
- Temperature and pH of treatment solution;
- Fruit drying efficiency;
- Packaging techniques – hand versus machine.

The study authors state that although these variables suggest potential differences in the processes, the impact on postapplication exposures to workers handling fruit downstream from the treatment area is insignificant. However, there are no means of verifying the validity of the study authors' statement. In fact, there is concern that averaging the exposures across all variables may underestimate postapplication exposures to certain workers, while overestimating exposures to other workers.

Attachment 1
Review by Versar, Inc.

Reviewer: Karie Riley/Susan Anderson **Date:** November 4, 2005 (Revised November 15, 2005)

STUDY TYPE: Post-application dermal and inhalation monitoring study in pear and citrus fruit packaging facilities

TEST MATERIAL: The test materials contained the active ingredient o-phenylphenol sodium salt (SOPP). In water, SOPP dissociates to establish an equilibrium between the o-phenylphenol anion (OPP^-) and undissociated o-phenylphenol (OPP). All analytical results were reported as OPP.

SYNONYMS: o-phenylphenol sodium salt: SOPP
o-phenylphenol: OPP

CITATION:

Study Author:	S.W. Maxey, P.G. Murphey
Title:	Evaluation of Post-Application Exposures to Sodium O-phenylphenate Tetrahydrate/O-phenylphenol to Workers during Post-Harvest Activities at Pear and Citrus Fruit Packaging Facilities.
Report Date:	October 19, 1994
Analytical Laboratories:	Industrial Hygiene Research and Technology Health and Environmental Sciences The Dow Chemical Company Midland, Michigan 48674
Identifying Codes:	MRID: 434329-01 Laboratory ID: HEH2.1-1-174(39)

SPONSOR: The Dow Chemical Company
Performance Products, Antimicrobial Group
Lerkin Laboratory
Midland, Michigan 48674

EXECUTIVE SUMMARY:

The study was designed to quantify worker exposure to o-phenylphenol sodium salt (SOPP) and o-phenylphenol (OPP) during post-harvest pear and citrus fruit handling activities. A total of 62 females were monitored at six fruit packaging facilities (3 pear and 3 citrus) that were using commercially available SOPP-based liquid formulations, containing 12% to 22% OPP. Though the test substances monitored contained SOPP as the active ingredient, all measurements in the Study Report were reported in terms of OPP. The pears were treated with SOPP through a dip application and the citrus were treated with SOPP through either a foam or spray application. The treatment solutions contained between 0.14 and 1.29% OPP. The processing method between the facilities varied, however, at all facilities, the fruit was rinsed with water after treatment and prior to any handling by the workers monitored in this study.

At each facility, a complete set of monitoring samples was collected from 5 sorters and 5 packers. The sorters inspected and graded treated fruit and the packers packaged treated fruit by hand or using a packaging machine (which also involved hand contact). All pear packers wore 2 to 3 cots on one hand to handle the pear packing paper and the majority of the pear packers also wore thin cotton gloves to protect their hands and fruit from physical damage. The citrus packers at one facility also wore gloves at times. The pear and citrus sorters did not wear gloves or cots, and a few workers wore tape at the end of fingers to protect the fruit.

Dermal exposure was monitored through the use inner dosimeters (t-shirt), outer dosimeters (long-sleeve shirt), and hand washes. Exposures were not monitored for body portions below the waist. Inhalation exposure was monitored through the use of personal air sampling equipment. The inhalation collection media consisted of a PVC filter and silica gel sorbent tube, which were placed at the breathing zone of each worker and attached to an air sampling pump calibrated to deliver an air flow rate of approximately 1.0 liter per minute (LPM). Additionally, area air monitoring samples were collected from various locations inside the citrus packaging facilities.

Using the data provided, Versar calculated OPP exposure estimates in mg/workday and in mg/hr. The mg/workday values were provided because many of the workers worked for more than 8 hours a shift (ranging from 6.6 to 10.2 hours/workday). The data were corrected by Versar for average field fortification recoveries at each facility when recoveries were below 90%. Residues less than the limit of detection (LOD) were set to ½ the LOD for all calculations.

Potential upper body dermal exposures, representing a worker wearing a short-sleeve shirt, were calculated by Versar by summing the levels determined from inner t-shirt dosimeters plus long sleeved shirt arm dosimeters. Potential upper body dermal exposures averaged 2.7, 4.3, and 3.6 mg/workday for pear packers at Facilities 1, 2, 3 respectively and 0.5, 0.15, and 0.8 mg/workday for citrus packers at Facilities 4, 5, and 6, respectively. Potential upper body dermal exposures averaged 6.2, 4.8, and 2.0 mg/workday for pear sorters at Facilities 1, 2, and 3, respectively. Citrus sorters demonstrated potential upper body dermal exposures averaging 2.8, 0.5, and 2.6 mg/workday at Facilities 4, 5, and 6, respectively.

Exposure to the hands was monitored by collection of hand rinse samples. Some of the workers wore thin cotton gloves in order to protect their hands from cuts and also to protect the fruit during post-application handling. Residue already present on the gloves or residue from the post-harvest fruit handling by participants in this Study remaining on these gloves was not considered in this Study. Using this sampling procedure, exposure to the hands averaged 0.4, 0.7, and 0.2 mg/workday to pear packers at Facilities 1, 2, and 3, respectively. Citrus packers averaged hand exposures of 1.0, 0.2, and 0.3 mg/workday at Facilities 4, 5, and 6, respectively. Sorters of pear fruit averaged residue levels of 2.2, 2.4, and 0.86 mg/workday at Facilities 1, 2, and 3, respectively. Sorters of citrus fruit averaged residue levels of 1.8, 0.6, and 2.2 mg/workday at Facilities 4, 5, and 6.

Total inhalation exposures were calculated by Versar using the NAFTA recommended breathing rate of 16.7 L/min for light activities. Potential inhalation exposures averaged 0.7, 0.8, and 0.7 mg/workday for pear packers at Facilities 1, 2, 3 respectively and 0.03, 0.008, and 0.1 mg/workday for citrus packers at Facilities 4, 5, and 6, respectively. Inhalation exposure averaged 1.1, 1.2, and 0.5 mg/workday for pear sorters at Facilities 1, 2, and 3, respectively. Citrus sorters demonstrated potential inhalation exposures averaging 0.2, 0.1, and 0.6 mg/workday at Facilities 4, 5, and 6, respectively.

Area air monitoring was also conducted at the citrus packaging facilities. Versar calculated ambient air concentration at the facilities based on this monitoring data.

Versar performed statistical analyses of the datasets to determine if the data were normally or log normally distributed. For the analysis, replicates were categorized into 12 groups of 5-6 replicates each. These 12 groups represent all possible combinations of job function (packer or sorter), type of fruit handled (pear or citrus), and location (3 facilities for both pear and citrus). For each of these 12 groups, statistical tests were performed on inhalation, dermal, and hand exposure data (i.e., 36 data sets analyzed).

The normality and log normality of the datasets were determined using the Shapiro-Wilks test ($p \leq 0.05$) on the raw data and the log-transformed data, respectively. Perhaps due to the small sample sizes, normality testing was inconclusive; that is, non-normality was not significant, but also, non-log normality was not significant. Because normality and log normality testing on data was inconclusive, it is unclear how to characterize the central tendency for these data. Therefore, both geometric and arithmetic means are presented in the exposure tables in this review.

The major issues of concern in evaluation of the study include:

- Potential lower body dermal exposure was not monitored. No dosimeter collection occurred for the body area below the waist. The Registrant reported that pre-survey visual observations showed a lack of contact with treated fruit with portions of the body below the waist.

- Dermal exposure data was not collected from the face/neck area.

- These postapplication dermal and inhalation studies following postharvest treatments to citrus and pears included many variables. The study authors state that although these variables suggest potential differences in the processes, the impact on postapplication exposures to workers handling fruit downstream from the treatment area is insignificant. However, Versar has no means of verifying the validity of the study authors' statement. In fact, Versar is concerned that averaging the exposures across all variables may underestimate postapplication exposures to certain workers, while overestimating exposures to other workers. The variables in the study include:
  1.fruit type – citrus and pears,
  2.formulation types ,
  3.fruit treatment method – dip versus spray or foam,
  4.fruit coating – wax layer versus no overcoat,
  5.worker proximity to the treatment area,
  6.time worker spends in facility – less than 8 hours up to 12 hours,
  7.facility size and ventilation equipment– might particularly affect inhalation exposures,
  8.concentration of SOPP in the treatment solution,
  9.control of pH in treatment solution (which affects conversion from SOPP to OPP),
  10.temperature of the postharvest treatment solution,
  11.fruit drying techniques and exposure setting – handling wet fruit versus dry fruit,
  12.how fruit is moved from the treatment to packaging area, and
  13.packaging techniques – hand versus machine

  Given these variables, Versar questions whether use of either the overall mean or geometric mean, as appears to be suggested by the study authors, to estimate dermal or inhalation exposures produces a valid estimate of the possible range of exposures that individual workers may experience under the various conditions experienced during postharvest applications to fruit in a packaging facility.

- Some of the workers wore hand protection during monitoring to protect the hands and fruit from physical harm. Items worn by some of the workers included thin cotton gloves which had been previously worn during handling of SOPP-treated fruit, cots on 2 to 3 fingers, and tape on the ends of fingers. According to the study author, it is common practice and in some facilities, mandatory, for workers in post-application areas to wear gloves, although this is not a label-specified requirement.

- Exposure to the hands was monitored by collection of hand rinse samples. Some of the workers wore thin cotton gloves in order to protect their hands from cuts and also to protect the fruit during post-application handling. Residue already present on the gloves or residue from the post-harvest fruit handling by participants in this Study remaining on these gloves was not considered in this Study. Gloves worn by some of the workers were not pre-washed and had been used in previous fruit handling events. The gloves may have contained dried SOPP/OPP residue. Also some of the residue present on fruit handled during this sampling event may have remained on the gloves and not transferred to the hand of the workers. Consequently, hand exposures may be over- or under-estimated by use of this sampling protocol.

- At each citrus facility, two of the five citrus sorters were monitored at the pre-sorting area while the remaining three citrus sorters were monitored at the main sorting area. The pre-sorters handled fruit immediately after SOPP treatment and the main sorters handled fruit further along in the packaging process. Pre-sorters were not monitored at the pear facilities.

- The test substances used were not identified and labels were not provided in the Study Report. Therefore, it could not be determined if the maximum application was used and if the product was used according to label directions.
- The Study Report did not identify the amount of fruit handled by each person.
- Exposure could not be normalized to mg/lb ai handled as is the usual EPA procedure. It was not possible to quantitate the amount of pesticide handled by each worker given the data provided in the Study Report.

This study met most of the Group B 875.1200 (dermal exposure) and 875.1400 (inhalation exposure) Guidelines. The issues of concern are:

- It was not clear as to whether or not the Study Protocol was approved by EPA.
- Study protocol deviations were not provided.
- Personal air monitoring pumps were set to only 1.0 L/min.
- Only two field fortification samples per fortification level were spiked.

COMPLIANCE:
Signed and dated GLP, Data Confidentiality statements, and Quality Assurance statements were provided in the Study Report. The Study Report states that it meets FIFRA Good Laboratory Practices 40 CFR part 160 with the following exceptions: (1) because the formulation used at each facility was not a Dow product, control of the test material used at each facility was not possible. Therefore, the test material used at each test facility could not be assayed prior to initiation of the study. Each packaging facility used a formulation of the test material that was different. Samples were collected of each formulation at each facility at the time of the survey to verify the SOPP/OPP concentration. In addition, the specific formulation at each facility was used to fortify the quality assurance samples, and (2) the formulation (test material) containers could not be maintained during the course of the study.

GUIDELINE OR PROTOCOL FOLLOWED:
The Dow Chemical Company Protocol was provided in the Study. The Study Report states that the data requirements were FIFRA Guideline No. 233 and 234 and Data Call-In for SOPP dated August 12, 1992.

I. MATERIALS AND METHODS

A. MATERIALS

1. Test Material:

Commercial formulations containing SOPP as the active ingredient were used at all test facilities in the study. The same manufacturer's formulation was used at all pear packaging facilities (Facilities 1, 2, and 3). The concentration of OPP found in each formulation being used at each pear facility was approximately 21% by weight. A different manufacturer's formulation was used at Facility 4 and Facility 5 (citrus facilities). This formulation had average OPP concentrations of 21 to 22% by weight. Facility 6, also a citrus facility, used a third manufacturer's formulation where the concentration of OPP was found to be 12% by weight. No further details were provided on the test formulation, such as product name, lot number, EPA Registration Number or the nominal percent active ingredient. According to the study protocol, the formulation was liquid. The CAS # of SOPP is 6152-33-6 and the CAS # of OPP is 464-70.

2. Relevance of Test Material to Proposed Formulation(s):
No information besides the concentration of the formulation was provided in the Study Report; therefore, Versar could not determine the relevance of the test material to the proposed formulations. However, the test material seems to be similar to the currently active SOPP-containing products that are used for post-harvest treatment of citrus and pears in packaging facilities.

B. STUDY DESIGN

Amendments or deviations from the study protocol were not reported.

1. Site Description

Test locations: Exposures were monitored at six fruit packaging facilities, including three pear and three citrus facilities. The pear packaging facilities were located in the Wenatchee Valley in Peshastin and Cashmere, Washington (Facilities 1, 2, and 3). The citrus facilities were located in Fort Pierce, Florida; Orange, California; and Redlands, California (Facilities 4, 5, and 6). The three pear packing facilities were considered representative of other pear packaging facilities and included facilities with older equipment where the potential for exposure may be greater than that at a more modern facility. The process of pear treatment and packaging was similar at the three facilities. The three citrus packaging facilities were also considered representative of the citrus fruit packaging facilities that use formulations containing SOPP. The general process of treating, grading, and packaging citrus fruit was similar to those at pear packaging facilities.

Meteorological Data: Environmental conditions during the sampling period were monitored periodically inside each packaging facility, and, if isolated, in the quality assurance sampling area during the monitoring period. Measurements were collected three to seven times a day using a Bacharach Model 7011 sling psychrometer. In addition, some general outdoor weather observations were obtained. The data collected is presented in Table 1 below.

Table 1. Meteorological Conditions

Facility	Date	Dry Bulb Temperature Range (°F)	Wet Bulb Temperature Range (°F)	Relative Humidity Range (%)	Outdoor Conditions
Pear Facilities					
1	9/28/93	61-81	53-71	50-62	Sunny
2	9/30/93	66-78	58-64	46-64	Sunny and clear
3	10/4/93	72-75	60-64	50-56	Overcast
Citrus Facilities					
4	1/25/94	72-80	67-71	62-78	Sunny, breezy, few clouds
5	2/15/94	62-70	53-61	54-58	Sunny, few clouds
6	2/17/94	52-59	49-54	53-82	Overcast, rain, damp

Ventilation/Air-Filtration:

Pears: Passive ventilation was used at pear facilities (large open access areas and doors into the facility). At Facility 1, a fraction of recirculated air from the dryer was vented out of the facility. At Facility 3, the ceiling had open vents and the dryer recirculated all air (no air vented).

Citrus: General ventilation, consisting primarily of ceiling fans, was present in all facilities and all the dryers were vented to the ceiling to vent the dryer combustion products and minimize heat build-up.

4. Number and type of workers:

A total of 62 workers participated, including 2 alternatives for which dermal deposition measurements to the hands were not collected. Complete exposure measurements were collected from 30 participants at 3 pear packing facilities and 30 participants at three citrus packaging facilities. The monitoring was split between two job classifications; those who grade and sort fruit (sorters) and those who package fruit (packers). Each individual who volunteered to participate was female because the job positions were exclusively held by females. At the time of the study, each participant was currently employed by a specific pear or citrus packaging facility and performing fruit handling operations in post-application areas of that facility. Each participate performed these work activities as apart of the daily job responsibilities. An Informed Consent Form was signed by each participant.

5. Protective clothing:

According to the Study Report, workers at pear and citrus packing facilities typically wear gloves in an effort to protect the fruit and their hands from cuts, punctures, and constant wetness. The participants were asked not to wear gloves during the sampling interval, but many participants wore thin cotton gloves because of the physical damage that would have occurred to the hands in fruit handling and box building operations if gloves were not worn. According to the Study Report, the gloves worn were typically much worn and had treatment material incorporated into them from weeks of past use. In some facilities, management required some sorters to wear tape on the tips of the fingers to cover longer fingernails in order to protect the fruit. All participants were instructed to wear what was necessary to conduct their jobs safely and effectively. This included plastic finger cots (2 to 3 cots on one hand only) for pear packers for handling the pear wrap paper. The hand protections worn by the workers are identified below.

Pear Packers: All pear packers wore gloves and cots, except for packer 12 and 14 at Facility 3. Packer 12 wore tape on the fingers and cots and packer No. 14 only wore cots.

Citrus Packers: Workers at Facility 4 (packers 17 to 21) and at Facility 5 (packers 22 to 26) did not wear any hand protection. All workers at Facility 6 (packers 27 to 31) wore gloves at times.

Pear Sorters: Workers at Facility 1 (sorters 1 to 5) and Facility 2 (sorters 6 to 11) did not wear any hand protection. At Facility 3, sorters 12 and 16 did not wear any hand protection, sorter 13 wore a band aid on the thumb, and sorter 14 and 15 wore tape on the ends of the fingers.

Citrus Sorters: Workers at Facility 4 (sorters 17 to 21) and Facility 5 (sorters 22 to 26) did not wear any hand protection. At Facility 6 (sorters 27 to 31), all sorters wore tape on the end of the fingers.

All workers wore a long-sleeve cotton/polyester blend shirt (outer dosimeter) over a cotton t-shirt (inner dosimeter). Typically, workers in packaging facilities will wear short-sleeve shirts according to the Study Report.

6. Replicates:

Upper body dermal, inhalation, and hand rinse exposure measurements were collected from 30 participants at three pear packing facilities and 30 participants at three citrus packaging facilities. At all sites, except Facility 2, five sorters and five packers were monitored. At Facility 2, 6 sorters and 6 packers were monitored, which included an alternative packer and sorter. However, dermal deposition measurements to the hands were not collected from the alternative workers.

The sorters inspected and graded treated fruit and the packers packaged treated fruit. For pears, the packers used one hand to grab thin copperized paper and the other hand to grab pears to wrap each pear individually before placing them into a box which generally held 40 to 50 lbs of pears. Packers would rotate to different tubs to pack different sizes of pears throughout their shift, and typically packed between 180 and 300 boxes a day. For citrus, the packaging was performed by hand or by use of packaging machines. The operators of the packaging machines came in contact with the fruit periodically when the fruit machine needed adjustment and when hand packing operations were needed.

7. Application and Processing Description

Application Equipment: Pears: The pears were dipped into a 20,000 to 35,000 dip tank prior to the post-application exposure study.

Citrus: Prior to the conduct of the study, the treatment solution was applied directly to the fruit as a foam application (Facility 4) or a spray application (Facility 5 and 6) while rotating brushes distributed the treatment solution evenly to the surface of the fruit.

Equipment Calibration: Information on the calibration of the equipment was not provided.

Application rate(s): Pears: The solution containing the test substance was to be maintained at approximately 0.4% OPP by weight. Measured concentrations of the treatment solution ranged from 0.14 to 0.24% OPP. No further information, such as exposure time or treatment solution volume per pound of fruit was provided.

Citrus: The average concentration of the treatment solution was 0.543% OPP at Facility 4, 0.776% OPP at Facility 5, and 1.29% OPP at Facility 6. No further information, such as exposure time or treatment solution volume per pound of fruit was provided.

As labels were not provided with the Study Report, it could not be determined if the test substance was used at the maximum application rate.

Treatment solution: Pears: The dip tank solution was super-cooled to the same temperature as the pears (32-35°F). The solution contained sodium lignosulfate which floated the pears in the dip tank. Additionally, the dip tank solution was maintained at a high pH to avoid conversion to OPP and subsequent burning of the fruit.

Citrus: No further information on the treatment solution at the citrus packaging facilities was provided.

Other products applied: Other products applied to the fruit at the packaging facilities included natural soaps, other fungicides (products not specified), and wax (except at Facility 2).

Processing Regime: Pears: The pears were received from orchards in 4 x 4 x 4 feet wood storage bins. The bins were placed in cold storage to achieve a pear core temperature of 32-35°F. Bins containing the pears were removed by forklift from cold storage and placed on a conveyor which introduced the entire bin to the dip tanks. After treatment, pears were conveyed out of the dip tank solution and onto the pear conveyor system where the cleaning phase began. Cleaning consisted of a mechanism to remove leaves and debris followed by a wash with neutral soap solution and a rinse with water. At this point, there is a pre-sort station which is used when the general pear quality is poor in order to remove damaged fruit. This pre-sort station was not used at any of the three pear packaging facilities. Following the cleaning phase, other fungicides were applied. At Facilities 1 and 3, wax was then applied to the fruit. Next, the fruit was dried. The drying phase consisted of fans and/or long dryer units that recirculated air at 130-140°F. After the drying phase, the pears were sorted by sorters into different grades, based on appearance and quality. After grading and sorting, each pear was individually weighed by an automated system and then conveyed to the proper pear collection tubs for packing. Packers used one hand to grab thin copperized paper and the other hand to grab pears to wrap each pear individually before placing them into a box which generally held 40 to 50 pounds of pears. Packers would rotate to different tubs to pack different sizes of pears through their shift. They typically

packed 180 to 300 boxes a day. Table 2 identifies processing differences that existed at the pear packaging facilities

Table 2: Process Differences at the Pear Packaging Facilities

Parameter	Facility 1	Facility 2	Facility 3
Worker ID	Sorter 1-5 Packer 1-5	Sorter 6-11 Packer 6-11	Sorter 12-16 Packer 12-16
Number of packaging Lines	2 large separate lines	1 smaller line	2 large separate lines
Height of ceilings	30 to 35 feet	10-12 feet	35-40 feet
Wax	Wax applied	No wax (dryer not used)	Wax applied
Ventilation	Passive ventilation. General ventilation in ceiling not operating. A fraction of re-circulated air from dryer was vented out of facility	Passive ventilation. Local cooling fans present though not used.	Passive ventilation. Ceiling had open vents. Dryer recirculated all ai, no air vented.
Sorting Area	Open sorting area	Enclosed sorting room	Open sorting room
Treatment Solution	Metered in formulation and water separately at constant rates.	Formulation placed into tank via bucket as needed when water was added to dip tank.	Formulation was diluted with water in a holding tank. This solution was metered into the tank at a constant rate.
Process Overview	SOPP/soap/rinse/fungicides/sponge/brushes/wax/pre-sort area/dryer/sort area/weigh station/packing bins	SOPP/soap/rinse/fungicides/ pre-sort area/fans/sort area/weigh station/packing bins	SOPP/soap/rinse/rinse/rinse/fungicides/sponge brushes/wax/pre-sort area/dryer/sort area/weigh station/packing bins

Citrus: Citrus fruit was brought directly from the orchard in large open trucks and mechanically conveyed into the packaging facility. The first step included cleaning the fruit using high pressure water rinses to remove dirt, leaves and debris. This was followed by a chlorine spray solution treatment to kill surface bacteria. In some cases, a pre-sort station was present for workers to sort out damaged fruit before the treatment phase. The next phase was the treatment phase, which consisted of using either foam (Facility 4) or spray (Facility 5 and Facility 6) application directly onto the fruit followed by brushing. A water rinse was applied immediately after the treatment and included a second segment of cleaning brushes. After treatment, sorters separated out damaged fruit at a pre-sort station. At Facilities 5 and 6, this area was in a small tented area and at Facility 4; this area was a large open area. These pre-sort stations were closest to the treatment area and the surface of the fruit was generally wet from the rinse with water following the treatment. After the pre-sort station, a wax and other fungicides were applied to the fruit and the fruit were then conveyed into a large recirculating dryer system which was maintained at 120 to 140°F. The fruit were then moved to the main sorting and grading area where fruit was sorted into appropriate grades, weighed using an automated system, and conveyed to the proper packaging area. Packaging was performed by hand and though the use of packaging machines. Periodically the operators of the packaging machines came into contact with the fruit periodically when the fruit on the machine needed adjustment and when hand packing operations were needed. Table 3 identifies processing differences that existed at the citrus packaging facilities.

Table 3: Process Differences at the Citrus Packaging Facilities			
Parameter	Facility 4	Facility 5	Facility 6
Worker ID	Sorter 17-21 Packer 17-21	Sorter 22-26 Packer 22-26	Sorter 27-31 Packer 27-31
Treatment type	Foam	Spray	Spray
Rinse after SOPP treatment	Spray rinse followed by brushes	Spray rinse followed by brushes	Hot water (105°F) rinse
Pre-sort area	Large open area	Small tented area	Small tended area
Packing process	Hand pack only	Packing machines and hand pack	Packing machines and hand pack

8. Exposure monitoring methodology:

Inhalation: Airborne SOPP/OPP was collected on a closed faced, 37-mm diameter Gelman GLA 5000 polyvinylchloride (PVC) filter in a plastic cassette followed in a series by a SKC 780-mg silica gel sorbant tube. The filter and tube sample train were used to collect both particulate and vapor components of SOPP and OPP in air. Each silica tube contained two sections of adsorbent; the second section was used to detect breakthrough from the first section. Air was pulled through the filter cassette and sampling train tube at a rate of approximately 1 liter per minute via portable battery operated SKC Flow-lite vacuum pumps which were connected to tubes using flexible tubing. The sample trains were connected to the lapel of each study participant's work shirt. Each pump was pre- and post-calibrated with a rotameter that was calibrated against an electric bubble flow meter before and after every survey segment. After sampling, tubes and cassettes were tightly capped, placed in sealed zip lock bags and stored in coolers with dry ice. Samples were transported via overnight shipment in coolers with dry ice to the Health and Environmental Sciences Analytical Chemistry Laboratory of the Dow Chemical Company for analysis. Samples were placed into the laboratory freezer upon arrival at the laboratory.

Air: The same technique used for personal air monitoring was used to monitor ambient air monitoring at the citrus packaging facilities. Supplemental monitoring was not conducted in the pear portion of the study. The purpose of this monitoring was to better define sources of potential exposure.

Outer Dosimeter: The outer dosimeter consisted of a clean cotton/polyester blend work-shirt issued prior to the start of the work shift. Immediately after the monitoring period, the shirt was collected and sectioned into two dosimeter samples, one representing the arms from just above the elbow to the wrist (both arms combined into one sample) and the other representing the torso region (collectively considered the stomach, back, chest, shoulders, and upper arms). A diagram on Page 130 of Study Report shows the cutting scheme of the outer dosimeter. The arm dosimeters were collected and shipped frozen in ½ gallon jars and the torso dosimeters were collected and shipped frozen in 1 gallon jars.

Inner Dosimeter: Each participant was issued a clean cotton t-shirt to wear underneath the outer dosimeter. The t-shirt was retained as a single sample. Following the post-application sampling event, the t-shirts were collected and shipped frozen in ½ gallon jars.

Hand Wash: Hand rinses were used to evaluate deposition on the hands. The hand rinses were collected from the workers when they would normally wash their hands after they came off the line. This included, but was not limited to, trips to the bathroom, period of eating or smoking, breaks, and at the end of the work period. Hand rinses were not collected from the two alternates at Facility 2. Gloves and fingers cots were removed prior to performing the hand rinse procedure. Any tape worn on the end of the fingers was kept on during the hand rinse procedure.

The hand rinse procedure included an initial wash with approximately 250 mL of soap solution (0.008% Emcol 4500) which was poured over the participant's hands into a stainless steel bowl, followed by a 250 mL hand rinse of distilled water. During the washing procedure, participants vigorously rubbed their hands together to physically dislodge residual material. The hand wash solution was then transferred using a stainless funnel into a 32-ounce glass bottle that contained 15 grams of analytical grade sodium chloride. After a short period to allow the salt to dissolve in the rinse solution, 200 mL of ethyl acetate was added to extract the SOPP/OPP and the sample was shaken for approximately 10 minutes. The salt enhances the separation of the polar and non-polar phase. Duplicate 30 mL samples of the extract were pipetted to 40 mL VOC vials, capped, and placed in coolers with dry ice in the field. Samples were transported in coolers containing dry ice to the laboratory. Samples were placed in the laboratory freezer upon arrival at the laboratory.

C. ANALYTICAL METHODOLOGY:

1. Sample Extraction/Detection:

Extraction methods:

Inhalation and Air: The filter and support pad were desorbed as a single sample, while the tube front and back were separated and desorbed individually. Each portion was desorbed with 5 mL of acetonitrile for an hour (agitated using a flat-bed shaker) followed by analysis by gas chromatography with flame-ionization detection (GC/FID).

Outer Dosimeter: The sleeves were extracted with 200 mL acetonitrile and the torso sections were extracted with 750 mL acetonitrile. Once the solvent was added, the samples were allowed to set on the bench in the lab overnight with period shaking, followed by an aliquot being removed for GC/FID analysis.

Inner Dosimeter: The full t-shirt was extracted in 750 mL of acetonitrile in the same manner as described for the outer dosimeters.

Hand Wash: The samples were extracted in the field with ethyl acetate and supplicate aliquots of the extract were analyzed using GC/FID.

Detection methods: Capillary gas chromatographs were used to analyze the samples from this study. Hewlett Packard Model 5890 gas chromatographs equipped with Model 7673 autosamplers were used to perform the analysis. Details of typical conditions are described in Table 4.

Table 4. Summary of GC/FID Conditions

Detector	Flame Ionization
Column	0.32 mm x 30 mm DB-5, 1μm film
Carrier Gas	Nitrogen
Head Pressure	8 psi
Injection Type	Splitless (purge on at 0.5 min)
Injection volume	1 μL (duplicate)
Split Vent flow rate	20 mL/min
Injection port Temperature	300°C
Injection Port Liner	Single gooseneck with glass wool plug

Oven Temperature Program for Non-Isothermic Runs	Initial: 90°C Rate: 20°C/min Final: 260°C Hold Time: 3.5 min
Oven Temperature for Isothermic Runs	200°C
Detector Temperature	300°C

Method validation: The analytical method was validated for each matrix. The average recovery for filter-tube spikes was 91.9±19% over a loading range of -5 to 4600 μg SOPP. The method was validated for sampling rates up to 1 L/min and a maximum total sample volume of 480 L. The average recovery for hand wash solutions was 112 ±9.45% over a SOPP concentration range of 0.4 to 100 μg/mL. According to the Study Report, the recovery for this method is greater than 100% due to some of the ethyl acetate dissolving in the hand wash solution, which results in a concentrating effect on SOPP. The average recovery of the outer dosimeter (long sleeve shirt) was 92.3±3.29% over a concentration range of 0.10 to 9.4 μg/cm^2. The average recovery of the t-shirts was 98.8±7.72% over an SOPP concentration range of 0.14 to 14 μg/cm^2. OPP spikes were also prepared with the dosimeters validated in the study. Recoveries for the dosimeters spiked OPP were all in excess of 95% and were comparable to the recoveries obtained for the SOPP spikes.

According to the Study Report, the linear range of the method was originally reported in the method validation report to extend from about 0.5 to 150 μg/mL, and have an estimated limit of detection (LOD) of approximately 0.5 μg/mL. The analysis conditions that yielded this dynamic range were used for the analysis of samples collected at the pear packaging facilities, and thus the limit of detection of 0.5 μg/mL was reported for those samples. Prior to analysis of the samples from the citrus packaging facilities, it was learned that the dynamic range of the analysis method could be extended to about 0.08 to 180 μg/mL, with a limit of detection of 0.08 μg/mL. The samples from citrus packaging facilities were analyzed using this extended dynamic range and lower limit of detection levels.

Instrument performance and calibration: Standards of SOPP in the appropriate extraction solvent were used for instrument calibration and were run with each sample set. Standards were used to determine either a mean response factor or the calculation of the calibration equation by performing linear regression on the analysis data for the standards.

Quantification: Quantification of SOPP levels in the samples was carried out using the external standards technique.

2. Quality Control:

Lab Recovery: Spikes were prepared in the laboratory and were included as part of each sample set analyzed. The average recoveries reported by the study author for air monitoring, hand wash and clothing dosimeters were 102±11.4%, 110±15.2%, and 109±18.2%, respectively.

Field blanks: Two field blank samples were analyzed per media at each site. Residues above the limit of detection were found in the shirt torso samples at Facility 4 (average of 82.6 μg/sample), the shirt arm samples at Facility 5 (average of 15.3 μg/sample), in the shirt arm samples at Facility 6 (average of 20.8μg/sample), and in the shirt torso samples at Facility 6 (average of 57.7 μg/sample). For inhalation samples, residues above the limit of detection were found in the blank samples at Facility 1 (average of

1.91 μg), Facility 2 (average of 3.96 μg), Facility 4 (average of 0.97 μg), and Facility 5 (average of 0.94 μg). The residues in the spikes field fortification samples were corrected for these background residues.

Field recovery: Field fortification samples were prepared at two fortification levels for each matrix. For the inhalation samples, the sample train consisted of a fortified filter with a blank tube (filter spike) or a blank filter with a fortified tube (tube spike). A summary of the results verified by Versar is provided in Table 5 (dermal dosimeters) and Table 6 (OVS tubes and filters). The recoveries were corrected for residues found in blank samples by the Registrant and Versar.

Table 5. Summary of Dermal Dosimeter Field Fortification Results [a,b]

Matrix	Fortification Level (μg/sample)	Recovery (%)	Average Recovery (%)	Standard Deviation (%)
Facility 1				
Shirt Arm	703	126.0	128.5	NA
		131.0		
Shirt Torso	703	110.2	105.2	NA
		100.1		
	70300	78.4	77.2	NA
		76.0		
	Overall		91.2	16.7
T-Shirt	633	87.8	89.6	NA
		91.3		
	7030	106.7	102.9	NA
		99.1		
	Overall		96.2	8.42
Hand Wash	351	119.1	121.2	NA
		123.4		
	35150	114.9	117.2	NA
		119.5		
	Overall		119.2	3.44
Facility 2				
Shirt Arm	195	104.6	120.0	NA
		135.4		
	19490	81.1	83.6	NA
		86.2		
	Overall		101.8	24.6
Shirt Torso	696	74.1	73.7	NA
		73.3		
	69600	63.1	63.6	NA
		64.1		
	Overall		68.6	5.87
T-Shirt	627	81.8	96.0	NA
		110.2		
	6963	86.2	93.1	NA
		100.1		

Table 5. Summary of Dermal Dosimeter Field Fortification Results [a,b]				
Matrix	Fortification Level (μg/sample)	Recovery (%)	Average Recovery (%)	Standard Deviation (%)
	Overall		94.6	13.0
Hand Wash	348	101.4	101.9	NA
		102.3		
	34815	113.5	111.9	NA
		110.3		
	Overall		106.9	5.93
Facility 3				
Shirt Arm	175	90.3	94.6	NA
		98.9		
	17510	89.1	87.4	NA
		85.7		
	Overall		91.0	5.61
Shirt Torso	62500	98.6	97.8	NA
		97.1		
	625	106.6	107.5	NA
		108.5		
	Overall		102.7	5.67
T-Shirt	562	107.3	106.0	NA
		104.8		
	6253	99.8	100.5	NA
		101.2		
	Overall		103.3	3.41
Hand Wash	313	70.6	71.9	NA
		73.2		
	31265	111.3	111.0	NA
		110.7		
	Overall		91.4	22.6
Facility 4				
Shirt Arm	191	51.2	59.3	NA
		67.5		
	18430	47.2	49.2	NA
		51.3		
	Overall		54.3	9.05
Shirt Torso	683	64.5	69.9	NA
		75.3		
	68300	63.9	63.3	NA
		62.7		
	Overall		66.6	5.87
T-Shirt	6826	87.3	90.9	NA
		94.5		
	614	107.5	100.7	NA
		94.0		

Table 5. Summary of Dermal Dosimeter Field Fortification Results [a,b]

Matrix	Fortification Level (µg/sample)	Recovery (%)	Average Recovery (%)	Standard Deviation (%)
	Overall		95.8	8.44
Hand Wash	341	103.8	108.1	NA
		112.3		
	34130	100.8	98.4	NA
		96.1		
	Overall		103.2	6.83
Facility 5				
Shirt Arm	178	106.4	101.1	NA
		95.7		
	17202	102.8	96.7	NA
		90.6		
	Overall		98.9	7.08
Shirt Torso	637	143.5	124.7	NA
		106.0		
	63700	106.8	101.8	NA
		96.9		
	Overall		113.3	20.6
T-Shirt	573	99.8	104.1	NA
		108.4		
	6370	112.6	115.6	NA
		118.7		
	Overall		109.9	7.92
Hand Wash	319	114.7	114.3	NA
		113.8		
	31855	113.6	114.3	NA
		114.9		
	Overall		114.3	0.640
Facility 6				
Shirt Arm	166	108.6	106.4	NA
		104.3		
	15932	109.1	112.7	NA
		116.4		
	Overall		109.6	5.01
Shirt Torso	59100	109.7	109.3	NA
		108.9		
	591	103.6	102.7	NA
		101.7		
	Overall		106.0	3.91
T-Shirt	532	125.0	119.9	NA
		114.8		
	5912	134.5	128.5	NA
		122.5		

Table 5. Summary of Dermal Dosimeter Field Fortification Results [a,b]

Matrix	Fortification Level (μg/sample)	Recovery (%)	Average Recovery (%)	Standard Deviation (%)
	Overall		124.2	8.10
Hand Wash	296	118.2	121.5	NA
		124.7		
	29560	113.7	116.5	NA
		119.4		
	Overall		119.0	4.52

[a] Recoveries calculated by Versar using raw data provided in Tables 4 through 9 of the Study Report.
[b] Residues corrected for the average blank residue.

Table 6. Inhalation Field Fortification Results[a,b]

Matrix	Fortification Level (µg/sample)	Number of Samples	Average Recovery (%)
Facility 1			
Filter	3.64	2	100
	141	2	93
Tube	3.64	2	111
	141	2	111
Overall		8	104±9.2
Facility 2			
Filter	3.46	2	128
	139	2	105.0
Tube	3.46	2	113
	139	2	116.6
Overall		8	116±29.8
Facility 3			
Filter	3.1	1	137
	125	2	102.8
Tube	3.1	2	130
	125	2	90.1
Overall		7	112±20.2
Facility 4			
Filter	2.48	2	99
	136	2	78.5
Tube	2.48	2	116
	136	2	99.3
Overall		8	98±15.6
Facility 5			
Filter	3.19	2	73
	127	2	83.6
Tube	3.19	2	138
	127	2	98.7
Overall		8	98±27.0
Facility 6			
Filter	3.1	2	77
	118	2	83.9
Tube	3.1	2	124
	118	2	110.8
Overall		8	99±20.9

[a] Recoveries calculated by Versar using raw data provided in Tables 10 through 15 of the Study Report.
[b] Residues corrected for the average blank residue.

Tank mix: The concentration of OPP in the dip tank treatment solutions used for pear treatment ranged from 0.14 to 0.24% OPP. For citrus treatment, the concentration of OPP in the treatment solutions ranged from 0.54 to 1.29%. The study author did not provide the conversion factor from SOPP to OPP.

Travel Recovery:

Travel fortification samples were prepared at two fortification level for shirt arms, t-shirts, hand washes, inhalation filters and inhalation tubes. For the inhalation samples, the sample train consisted of a fortified filter with a blank tube (filter spike) or a blank filter with a fortified tube (tube spike). A summary of the results verified by Versar is provided in Table 7. Overall recoveries were less than 90% for the t-shirt samples at Facility 1 (78.4%), t-shirt samples at Facility 2 (85.1%), shirt arm samples at Facility 3 (63.4%), and inhalation filter samples at Facility 3 (84.1%). The remaining average recoveries ranged from 91.7 to 127%. The recoveries were corrected for residues found in blank samples by the Registrant and Versar.

Table 7. Summary of Travel Recovery Samples

Matrix	Fortification Levels (μg)	Number of samples	Average Recovery (%)	Standard Deviation (%)
Facility 1				
Shirt Arm	Low: 14.6, High: 141	6	97.7	5.3
T-Shirt	Low: 9.46, High: 111	6	78.4	17.4
Hand Wash	Low: 39, High: 39680	4	100.2	3.8
Inhalation Filter	Low: 3.64, High: 141	6	125	21.8
Inhalation Tube	Low: 3.64, High: 141	6	127	15.6
Facility 2				
Shirt Arm	Low: 13.8, High: 139	6	102.9	12.7
T-Shirt	Low: 9, High: 97.5	6	85.1	15.1
Hand Wash	Low: 348, High: 34815	4	95.5	5.2
Inhalation Filter	Low: 3.46, High: 141	6	99.0	6.8
Inhalation Tube	Low: 3.64, High: 141	6	109	7.7
Facility 3				
Shirt Arm	Low: 14.2, High: 125	6	63.4	5.3
T-Shirt	Low: 9.11, High: 87.5	6	98.0	4.3
Hand Wash	Low: 313, High: 31265	4	91.7	18.2
Inhalation Filter	Low: 3.51, High: 125	6	84.1	3.9
Inhalation Tube	Low: 3.51, High: 125	6	103	4.5
Facility 4				
Shirt Arm	Low: 9.93, High: 137	6	115.9	10.9
T-Shirt	Low: 6.4, High: 95.6	6	120.5	29.0
Hand rinse	Low: 341, High: 34100	4	102.9	8.1
Inhalation Filter	Low: 2.48, High: 137	6	132	19.6
Inhalation Tube	Low: 2.48, High: 137	6	139	22.7
Facility 5				
Shirt Arm	Low: 12.8, High: 127	6	111.1	3.4
T-Shirt	Low: 8.29, High: 89.2	6	100.3	9.0
Hand Wash	Low: 319, High: 31855	4	124.5	11.5
Inhalation Filter	Low: 3.19, High: 127	6	95.9	4.4
Inhalation Tube	Low: 3.19, High: 127	6	108	4.9
Facility 6				
Shirt Arm	Low: 12.4, High: 118	6	102.2	6.4

Table 7. Summary of Travel Recovery Samples				
Matrix	Fortification Levels (μg)	Number of samples	Average Recovery (%)	Standard Deviation (%)
T-Shirt	Low: 8.06, High: 82.8	6	104.4	19.6
Hand Wash	Low: 296, High: 29560	4	113.6	4.7
Inhalation Filter	Low: 3.1, High: 118	6	98.8	14.8
Inhalation Tube	Low: 3.1, High: 118	6	105	10.4

Storage Stability: Storage stability evaluation of SOPP in hand washes, 100% cotton (t-shirt), 65% polyester/35% cotton (outer dosimeter), and filter-silica gel were conducted as part of the method validation study. Samples were stored for each of the following conditions: 1 month in ambient conditions, approximately 1 month in the freezer, and approximately 2 months in the freezer. Table 8 summarizes the results. The results indicate that air and hand wash samples are stable for up to 2 months frozen storage, but potential losses may occur from the outer dosimeter and inner dosimeter samples. To evaluate potential losses in the samples, field recovery and travel recovery samples were prepared for this study and the field samples were corrected for field recovery.

Table 8. Summary of Storage Stability Results				
Media	Target Spike Level (μg)	Average Recovery ± Standard Deviation (%)		
		1-month ambient	1-month freezer	2-month freezer
Silica Gel – stored at 80% relative humidity	5	80.2±3.36	80.2±3.22	83.3±4.7
	4,800	120±3.5	125±2.08	132±2.08
Silica Gel – stored at 30% relative humidity	5	--	126±26.4	--
	4,800	--	126±2.06	--
Hand Wash	0.4	94.0±4.18	93.0±1.93	102±3.47
	100	105±0.76	101±0.73	103±3.31
Outer dosimeter	10	93.3±13.9	78.1±6.00	60.0±0.81
	1,000	70.5±5.32	89.6±2.56	70.9±3.26
Inner Dosimeter	15	72.0±7.80	80.9±4.2	71.8±8.86
	1500	84.5±16.1	91.7±3.36	77.2±3.02

II. RESULTS AND CALCULATIONS:

A. EXPOSURE CALCULATIONS:

Potential Upper Body Dermal Exposure

Potential dermal exposure to packers and sorters was determined through the use of a t-shirt inner dosimeter, a long-sleeve shirt outer dosimeter and hand washes. Residues of SOPP were reported in terms of OPP in the Study Report (the conversion factor used was not provided). The Registrant adjusted the measured residues for all field fortification recoveries <100% and reported the potential dermal exposure in μg. Versar adjusted the measured residues for all field fortification recoveries <90% and reported the potential dermal exposure in mg/workday and mg/hr. The potential dermal exposure was adjusted to mg/hr using the inhalation monitoring times provided in the Study Report. Exposure in mg/workday was provided because many of the workers worked more than an 8 hr day. Whole body dosimetry was not used in conduct of this study. Potential exposure to areas of the body below the waist was not monitored. To calculate the potential upper body dermal exposure, both the Registrant and Versar summed the exposures for the inner t-shirt dosimeter and the arms of the outer shirt dosimeter (cut from above the elbow to the wrist). This represents a worker

wearing a short-sleeve shirt. According to the Study Report, a typical worker will wear a sort-sleeve shirt while sorting and packing. The potential upper body dermal exposures calculated by Versar are provided in Table 9 for packers and 10 for sorters. Because normality and log normality testing on data was inconclusive, it is unclear how to characterize the central tendency for these data. Therefore, both geometric and arithmetic means are presented in tables.

Versar calculated potential upper body dermal exposures ranging from 2.40 to 5.3 mg/workday for pear packers, from 0.11 to 1.1 mg/workday for citrus packers, from 0.91 to 11.6 mg/workday for pear sorters, and from 0.13 to 8.8 mg/workday for citrus sorters. Potential upper body dermal exposures, representing a worker wearing a short-sleeve shirt, were calculated by Versar by summing the levels determined from inner t-shirt dosimeters plus long sleeved shirt arm dosimeters. Potential upper body dermal exposures averaged 2.7, 4.3, and 3.6 mg/workday for pear packers at Facilities 1, 2, 3 respectively and 0.5, 0.15, and 0.8 mg/workday for citrus packers at Facilities 4, 5, and 6, respectively. Potential upper body dermal exposures averaged 6.2, 4.8, and 2.0 mg/workday for pear sorters at Facilities 1, 2, and 3, respectively. Citrus sorters demonstrated potential upper body dermal exposures averaging 2.8, 0.5, and 2.6 mg/workday at Facilities 4, 5, and 6, respectively.

Potential Hand Exposure

Potential hand exposure was estimated from hand wash residue samples. Potential hand exposures calculated by Versar are provided in Table 11 for packers and 12 for sorters. Because normality and log normality testing on data was inconclusive, it is unclear how to characterize the central tendency for these data. Therefore, both geometric and arithmetic means are presented in the Tables.

For hands only, potential dermal exposures ranged from 0.08 to 1.1 mg/workday for pear packers and from 0.07 to 2.6 mg/workday for citrus packers and from 0.6 to 3.2 mg/workday for pear sorters, and from 0.2 to 3.9 mg/workday for citrus sorters. Exposure to the hands averaged 0.4, 0.7, and 0.2 mg/workday to pear packers at Facilities 1, 2, and 3, respectively. Citrus packers averaged hand exposures of 1.0, 0.2, and 0.3 mg/workday at Facilities 4, 5, and 6, respectively. Sorters of pear fruit averaged residue levels of 2.2, 2.4, and 0.86 mg/workday at Facilities 1, 2, and 3, respectively. Sorters of citrus fruit averaged residue levels of 1.8, 0.6, and 2.2 mg/workday at Facilities 4, 5, and 6.

Potential Inhalation Exposure

Potential inhalation exposure was determined through the use of a PVC filter in a plastic cassette followed in a series by a SKC 780-mg silica gel sorbent tube. Residues of SOPP were measured in the filter and on the front and back of the tubes. All results were reported in terms of OPP in the Study Report (the conversion factor used was not provided). The Registrant adjusted the measured residues for all field fortification recoveries <100% to calculate the OPP concentration ($\mu g/m^3$). The Registrant did not employ a breathing rate in the exposure calculations. Versar adjusted the measured residues for all field fortification recoveries <90% and calculated inhalation exposure in mg/workday and mg/hr by using the NAFTA recommended breathing rate of 16.7 L/min for light activities. Exposure in mg/workday was provided because many of the workers worked more than an 8 hr day. The inhalation exposures calculated by Versar are provided in Table 13 for packers and Table 14 for sorters. Because normality and log normality testing on data was inconclusive, it is unclear how to characterize the central tendency for these data. Therefore, both geometric and arithmetic means are presented in the Tables.

Versar calculated potential inhalation exposures ranging from 0.384 to 0.9 mg/workday for pear packers, from 0.007 to 0.1 mg/workday for citrus packers, from 0.4 to 1.4 mg/workday for pear sorters, and from 0.007 to 1.5 mg/workday for citrus sorters. Potential inhalation exposures averaged 0.7, 0.8, and 0.7 mg/workday for pear packers at Facilities 1, 2, and 3 respectively and 0.03, 0.008, and 0.1 mg/workday for citrus packers at Facilities 4, 5, and 6, respectively. Inhalation exposure averaged 1.1, 1.2, and 0.5 mg/workday for pear sorters at Facilities 1, 2, and 3, respectively. Citrus sorters demonstrated potential inhalation exposures averaging 0.2, 0.1, and 0.6 mg/workday at Facilities 4, 5, and 6, respectively.

Ambient Air Concentration

The Study Report also reported results from ambient air monitoring at the citrus packaging facilities. Air concentration levels are presented in Table 15.

Special Statistical Analysis

Versar performed statistical analyses of the datasets to determine if the data were normally or log normally distributed. For the analysis, replicates were categorized into 12 groups of 5-6 replicates each. These 12 groups represent all possible combinations of job function (packer or sorter), type of fruit handled (pear or citrus), and location (3 facilities for both pear and citrus). For each of these 12 groups, statistical tests were performed on inhalation, dermal, and hand exposure data (i.e., 36 data sets analyzed).

The normality and log normality of the datasets were determined using the Shapiro-Wilks test ($p<=0.05$) on the raw data and the log-transformed data, respectively. Perhaps due to the small sample sizes, normality testing was inconclusive; that is, non-normality was not significant, but also, non-log normality was not significant.

Analysis of Variance (ANOVA) was performed on the 36 data sets to determine if significant differences exist in the results of the different facilities ($p<=0.05$). ANOVA was performed 12 times--once for each possible combination of data type (inhalation, dermal, and hand exposure), job function (packer or sorter), and type of fruit handled (pear or citrus). Each group of data for which ANOVA was performed consisted of three data sets, representing three facilities. Statistically significant differences were found for different facilities for the following populations and exposures: inhalation exposure for citrus packers, and pear sorters, upper body dermal exposure for pear packers, citrus packers, and pear sorters, hand exposure for pear packers, pear sorters and citrus sorters. ANOVA on non-transformed data demonstrated no statistically significant differences in the following populations and exposures: inhalation exposure for pear packers and citrus sorters, upper body exposure for citrus sorters and hand exposure for citrus packers.

III DISCUSSION:

A. CONCLUSION

In general, the sorters had higher exposures than packers and sorters in the pre-sort area had higher exposures than the sorters in the main sort area. The pre-sort area was immediately after the SOPP treatment phase in the process. However, only 2 pre-sorters and 3 main sorters were monitored per facility, thus preventing a statistical analysis of the results.

B. LIMITATIONS OF THE STUDY:

The major issues of concern in evaluation of the study include:

- Potential lower body dermal exposure was not monitored. No dosimeter collection occurred for the body area below the waist. The Registrant reported that pre-survey visual observations showed a lack of contact with treated fruit with portions of the body below the waist.

- Dermal exposure data was not collected from the face/neck area.

- This postapplication dermal and inhalation study following postharvest treatments to citrus and pears included many variables. The study authors state that although these variables suggest potential differences in the processes, the impact on postapplication exposures to workers handling fruit downstream from the treatment area is insignificant. However, Versar has no means of verifying the validity of the study authors' statement. In fact, Versar is concerned that averaging the exposures across all variables may underestimate postapplication exposures to certain workers, while overestimating exposures to other workers. The variables in the study include:
  1. fruit type – citrus and pears,
  2. formulation types ,
  3. fruit treatment method – dip versus spray or foam,
  4. fruit coating – wax layer versus no overcoat,
  5. worker proximity to the treatment area,
  6. time worker spends in facility – less than 8 hours up to 12 hours,

7. facility size and ventilation equipment– might particularly affect inhalation exposures,
8. concentration of SOPP in the treatment solution,
9. control of pH in treatment solution (which affects conversion from SOPP to OPP),
10. temperature of the postharvest treatment solution,
11. fruit drying techniques and exposure setting – handling wet fruit versus dry fruit,
12. how fruit is moved from the treatment to packaging area, and
13. packaging techniques – hand versus machine

Given these variables, Versar questions whether use of either the overall mean or geometric mean, as appears to be suggested by the study authors, to estimate dermal or inhalation exposures produces a valid estimate of the possible range of exposures that individual workers may experience under the various conditions experienced during postharvest applications to fruit in a packaging facility.

- Some of the workers wore hand protection during monitoring to protect the hands and fruit from physical harm. Items worn by some of the workers included thin cotton gloves which had been previously worn during handling of SOPP-treated fruit, cots on 2 to 3 fingers, and tape on the ends of fingers. According to the study author, it is common practice and in some facilities, mandatory, for workers in post-application areas to wear gloves, although this is not a label-specified requirement.

- Exposure to the hands was monitored by collection of hand rinse samples. Some of the workers wore thin cotton gloves in order to protect their hands from cuts and also to protect the fruit during post-application handling. Residue already present on the gloves or residue from the post-harvest fruit handling by participants in this Study remaining on these gloves was not considered in this Study. Gloves worn by some of the workers were not pre-washed and had been used in previous fruit handling events. The gloves may have contained dried SOPP/OPP residue. Also some of the residue present on fruit handled during this sampling event may have remained on the gloves and not transferred to the hand of the workers. Consequently, hand exposures may be over- or under-estimated by use of this sampling protocol.

- At each citrus facility, two of the five citrus sorters were monitored at the pre-sorting area while the remaining three citrus sorters were monitored at the main sorting area. The pre-sorters handled fruit immediately after SOPP treatment and the main sorters handled fruit further along in the packaging process. Pre-sorters were not monitored at the pear facilities.

- The test substances used were not identified and labels were not provided in the Study Report. Therefore, it could not be determined if the maximum application was used and if the product was used according to label directions.

- The Study Report did not identify the amount of fruit handled by each person.

- Exposure could not be normalized to mg/lb ai handled as is the usual EPA procedure. It was not possible to quantitate the amount of pesticide handled by each worker given the data provided in the Study Report.

This study met most of the Group B 875.1200 (dermal exposure) and 875.1400 (inhalation exposure) Guidelines. The issues of concern are:

- It was not clear as to whether or not the Study Protocol was approved by EPA.

- Study protocol deviations were not provided.

- Personal air monitoring pumps were set to only 1.0 L/min.

- Only two field fortification samples per fortification level were spiked.

Table 9. Summary of Upper Body Exposures for Pear and Citrus Packers (mg/workday and mg/hr)

Facility No.	Worker No.	Hand protection	Work Location	Treatment type	Average OPP treatment concentration	Workday Duration (hr)[a]	Inner T-shirt Residue (mg)	Outer Arm Residue[c] (mg)	Upper Body Total Dermal Exposure[e] (mg)	Upper Body Total Dermal Exposure (mg/hr)
Pear Packers										
1	1	gloves/cots	Packing Line 1	Dip tank	1.4	8.8	1.00	1.51	2.51	0.285
1	2	gloves/cots	Packing Line 1	Dip tank	1.4	10.1	0.48	2.04	2.52	0.250
1	3	gloves/cots	Packing Line 2	Dip tank	0.207	10.2	0.99	1.56	2.55	0.250
1	4	gloves/cots	Packing Line 2	Dip tank	0.207	10.2	0.91	2.41	3.32	0.327
1	5	gloves/cots	Packing Line 2	Dip tank	0.207	10.0	1.08	1.38	2.46	0.245
						Facility 1 Geometric Mean			2.65	0.27
						Facility 1 Arithmetic Mean			2.67	0.27
						Facility 1 Standard Deviation			0.37	0.03
2	6	gloves/cots	Packing Line	Dip tank	0.23	9.6	1.07	3.3	4.37	0.454
2	7	gloves/cots	Packing Line	Dip tank	0.23	9.5	0.781	4.05	4.83	0.507
2	8	gloves/cots	Packing Line	Dip tank	0.23	9.6	0.761	3.21	3.97	0.413
2	9	gloves/cots	Packing Line	Dip tank	0.23	9.3	0.900	3.07	3.97	0.426
2	10	gloves/cots	Packing Line	Dip tank	0.23	9.4	0.746	4.29	5.04	0.537
2	11	gloves/cots	Packing Line	Dip tank	0.23	9.2	1.13	2.26	3.39	0.368
						Facility 2 Geometric Mean			4.22	0.45
						Facility 2 Arithmetic Mean			4.26	0.45
						Facility 2 Standard Deviation			0.61	0.06
3	12	tape/cots	Lines A and B	Dip tank	0.238	9.8	0.692	2.37	3.06	0.313
3	13	gloves/cots	Lines A and B	Dip tank	0.238	9.8	1.07	3.5	4.57	0.466
3	14	cots	Lines A and B	Dip tank	0.238	9.8	0.529	1.87	2.40	0.244
3	15	gloves/cots	Lines A and B	Dip tank	0.238	9.9	0.872	1.85	2.72	0.275
3	16	gloves/cots	Lines A and B	Dip tank	0.238	10.0	0.823	4.48	5.30	0.533
						Facility 3 Geometric			3.44	0.350
						Facility 3 Arithmetic Mean			3.61	0.366
						Facility 3 Standard Deviation			1.26	0.126
Citrus Packers										
4	17	none	hand pack	Foam	0.543	8.2	0.0592	0.287293[d]	0.35	0.043
4	18	none	hand pack	Foam	0.543	6.6	0.02415[b]	0.63167[d]	0.66	0.099
4	19	none	hand pack	Foam	0.543	8.2	0.106	0.40884[d]	0.51	0.063
4	20	none	hand pack	Foam	0.543	7.8	0.0242[b]	0.42173[d]	0.45	0.057
4	21	none	hand pack	Foam	0.543	7.5	0.0951	0.36832[d]	0.46	0.062
						Facility 4 Geometric Mean	0.05109	0.409569	0.475	0.0623
						Facility 4 Arithmetic Mean	0.06172	0.423573	0.485	0.0647
						Facility 4 Standard Deviation	0.03842	0.127624	0.113	0.0209
5	22	none	hand pack	Spray	0.776	9.4	0.0338[b]	0.117	0.15	0.016
5	23	none	hand pack	Spray	0.776	7.9	0.0338[b]	0.0767	0.11	0.014
5	24	none	hand pack	Spray	0.776	8.4	0.0338[b]	0.15	0.18	0.00218

Table 9. Summary of Upper Body Exposures for Pear and Citrus Packers (mg/workday and mg/hr)

Facility No.	Worker No.	Hand protection	Work Location	Treatment type	Average OPP treatment concentration	Workday Duration (hr)[a]	Inner T-shirt Residue (mg)	Outer Arm Residue[c] (mg)	Upper Body Total Dermal Exposure[e] (mg)	Upper Body Total Dermal Exposure (mg/hr)
5	25	none	hand pack	Spray	0.776	9.6	0.0338[b]	0.124	0.16	0.016
5	26	none	hand pack	Spray	0.776	8.5	0.0338[b]	0.108	0.14	0.017
						Facility 5 Geometric Mean	0.05356	0.112508	0.17864	0.02044
						Facility 5 Arithmetic Mean	0.09464	0.11514	0.20978	0.02422
						Facility 5 Standard Deviation	0.13604	0.026579	0.15657	0.01889
6	27	gloves at times	machine pack	Spray	1.29	8.2	0.142	0.691	0.83	0.102
6	28	gloves at times	machine pack	Spray	1.29	7.7	0.285	0.803	1.09	0.142
6	29	gloves at times	machine pack	Spray	1.29	8.1	0.188	0.524	0.71	0.088
6	30	gloves at times	machine pack	Spray	1.29	8.1	0.257	0.577	0.83	0.104
6	31	gloves at times	machine pack	Spray	1.29	7.5	0.222	0.348	0.57	0.076
						Facility 6 Geometric Mean	0.21257	0.566573	0.78951	0.09994
						Facility 6 Arithmetic Mean	0.2188	0.5886	0.8074	0.10220
						Facility 6 Standard Deviation	0.05634	0.172227	0.19076	0.02488

a. Workday duration is based on the monitoring duration, which was recorded for inhalation monitoring purposes.
b. ½ LOD was used if residues were reported as <LOD.
c. Includes both arms of long-sleeve outer dosimeter cut from above the elbow to the wrist.
d. Corrected for field fortification recovery of 54.3%
e. Total upper body dermal exposure is the sum of t-shirt and arm exposures and is representative of a worker wearing a short sleeve shirt.

Table 10. Summary of Upper Body Exposures for Pear and Citrus Sorters (mg/workday and mg/hr)

Facility No.	Worker No.	Hand protection	Work Location	Treatment type	Average OPP treatment concentration	Workday Duration (hr)[a]	Inner T-shirt Residue (mg)	Outer Arm Residue[c] (mg)	Upper Body Total Dermal Exposure[c] (mg)	Upper Body Total Dermal Exposure (mg/hr)
Pear Sorters										
1	1	None	Line 2 sort	Dip tank	0.207	10.2	0.990	3.42	4.41	0.434
1	2	None	Line 2 sort area	Dip tank	0.207	10.1	1.290	6.44	7.73	0.769
1	3	None	Line 1 sort	Dip tank	0.14	10.0	0.548	2.07	2.62	0.261
1	4	None	Line 1 sort	Dip tank	0.14	10.1	0.795	3.87	4.66	0.464
1	5	None	Line 2 sort	Dip tank	0.207	10.0	1.340	10.3	11.6	1.17
						Facility 1 Geometric Mean	0.943	4.486	5.46	0.543
						Facility 1 Arithmetic Mean	0.993	5.22	6.21	0.619
						Facility 1 Standard Deviation	0.334	3.25	3.55	0.357
2	6	None	In sort room	Dip tank	0.23	9.3	0.718	5.61	6.33	0.682
2	7	None	In sort room	Dip tank	0.23	9.4	0.622	5.03	5.65	0.599
2	8	None	In sort room	Dip tank	0.23	9.4	0.718	0.194	0.912	0.0968
2	9	None	In sort room	Dip tank	0.23	9.4	1.250	3.35	4.60	0.491
2	10	None	In sort room	Dip tank	0.23	9.3	3.580	1.24	4.82	0.518
2	11	None	In sort room	Dip tank	0.23	9.4	0.416	5.83	6.25	0.662
						Facility 2 Geometric Mean	0.918	2.26	4.07	0.434
						Facility 2 Arithmetic Mean	1.22	3.54	4.76	0.508
						Facility 2 Standard Deviation	1.19	2.38	2.01	0.215
3	12	None	Both sort lines	Dip tank	0.238	9.4	0.537	1.46	2.00	0.212
3	13	Band aid on thumb	Line a sorting	Dip tank	0.238	9.8	0.803	1.13	1.93	0.197
3	14	Tape on end of fingers	Line b sorting	Dip tank	0.238	9.7	0.485	1.32	1.8	0.185
3	15	Tape on end of fingers	Both sort lines	Dip tank	0.238	9.7	0.543	1.98	2.52	0.259
3	16	None	Line b sorting	Dip tank	0.238	9.8	0.405	1.22	1.62	0.166
						Facility 3 Geometric	0.540	1.39	1.96	0.202
						Facility 3 Arithmetic Mean	0.555	1.42	1.98	0.204
						Facility 3 Standard Deviation	0.149	0.335	0.337	0.0351
Citrus Sorters										
4	17	None	Main sort area	Foam	0.543	8.3	0.294	0.842[d]	1.14	0.138
4	18	None	Pre-sort area	Foam	0.543	8.6	0.316	1.676[d]	1.99	0.233
4	19	None	Pre-sort area	Foam	0.543	8.5	0.641	8.140[d]	8.78	1.03
4	20	None	Main sort area	Foam	0.543	8.6	0.106	1.015[d]	1.12	0.130
4	21	None	Main sort area	Foam	0.543	8.5	0.132	0.742	0.874	0.103
						Facility 4 Geometric Mean	0.242	1.54	1.81	0.214
						Facility 4 Arithmetic Mean	0.298	2.48	2.78	0.327
						Facility 4 Standard Deviation	0.213	3.18	3.38	0.397
5	22	None	Tented pre-sort	Spray	0.776	9.8	0.207	0.830	1.04	0.106
5	23	None	Main sort area	Spray	0.776	9.7	0.080	0.137	0.217	0.0224

Table 10. Summary of Upper Body Exposures for Pear and Citrus Sorters (mg/workday and mg/hr)

Facility No.	Worker No.	Hand protection	Work Location	Treatment type	Average OPP treatment concentration	Workday Duration (hr)[a]	Inner T-shirt Residue (mg)	Outer Arm Residue[c] (mg)	Upper Body Total Dermal Exposure[e] (mg)	Upper Body Total Dermal Exposure (mg/hr)
5	24	None	Tented pre-sort	Spray	0.776	9.6	0.275	0.553	0.828	0.0861
5	25	None	Main sort area	Spray	0.776	9.8	0.0338[b]	0.100	0.134	0.0137
5	26	None	Main sort area	Spray	0.776	9.8	0.0338[b]	0.152	0.186	0.019
						Facility 5 Geometric Mean	0.0877	0.249	0.341	0.0351
						Facility 5 Arithmetic Mean	0.126	0.354	0.480	0.0494
						Facility 5 Standard Deviation	0.109	0.323	0.420	0.0432
6	27	tape on end of fingers	Main sort area	Spray	1.29	8.2	0.621	3.78	4.40	0.535
6	28	tape on end of fingers	Tented pre-sort	Spray	1.29	7.8	1.010	4.25	5.26	0.673
6	29	tape on end of fingers	Tented pre-sort	Spray	1.29	8.2	0.095	0.70	0.793	0.0972
6	30	tape on end of fingers	Main sort area	Spray	1.29	8.1	0.153	1.33	1.48	0.183
6	31	tape on end of fingers	Main sort area	Spray	1.29	7.9	0.158	1.00	1.16	0.146
						Facility 6 Geometric Mean	0.270	1.72	1.99	0.248
						Facility 6 Arithmetic Mean	0.407	2.21	2.62	0.327
						Facility 6 Standard Deviation	0.398	1.67	2.06	0.259

a. Workday duration is based on the monitoring duration, which was recorded for inhalation monitoring purposes.
b. ½ LOD was used if residues were reported as <LOD.
c. Includes both arms of long-sleeve outer dosimeter.
d. Corrected for field fortification recovery of 54.3%
e. Total upper body dermal exposure is the sum of t-shirt and arm exposures.

Table 11. Potential Hand Exposure for Pear and Citrus Packers (mg/workday and mg/hr)

Facility No.	Worker No.	Hand protection	Work Location	Treatment type	Average OPP treatment concentration	Workday Duration (hr)	Total Potential Hand Exposure[b] (mg/workday)	Total Potential Hand Exposure[c] (mg/hr)
Pear Packers								
1	1	gloves/cots	Packing Line 1	Dip tank	1.4	8.8	0.629	0.071
	2	gloves/cots	Packing Line 1	Dip tank	1.4	10.1	0.291	0.029
	3	gloves/cots	Packing Line 2	Dip tank	0.207	10.2	0.455	0.045
	4	gloves/cots	Packing Line 2	Dip tank	0.207	10.2	0.288	0.028
	5	gloves/cots	Packing Line 2	Dip tank	0.207	10.0	0.138	0.014
						Facility 1 Geometric Mean	0.319	0.0324
						Facility 1 Arithmetic Mean	0.360	0.0374
						Facility 1 Standard Deviation	0.187	0.0220
2	6	gloves/cots	Packing Line	Dip tank	0.23	9.6	0.596	0.062
	7	gloves/cots	Packing Line	Dip tank	0.23	9.5	No sample	No sample
	8	gloves/cots	Packing Line	Dip tank	0.23	9.6	0.707	0.074
	9	gloves/cots	Packing Line	Dip tank	0.23	9.3	0.421	0.045
	10	gloves/cots	Packing Line	Dip tank	0.23	9.4	1.068	0.114
	11	gloves/cots	Packing Line	Dip tank	0.23	9.2	0.931	0.101
						Facility 2 Geometric Mean	0.707	0.0749
						Facility 2 Arithmetic Mean	0.745	0.0791
						Facility 2 Standard Deviation	0.259	0.0282
3	12	tape/cots	Packing Lines A and B	Dip tank	0.238	9.8	0.200	0.0204
	13	gloves/cots	Packing Lines A and B	Dip tank	0.238	9.8	0.143	0.0145
	14	cots	Packing Lines A and B	Dip tank	0.238	9.8	0.157	0.0159
	15	gloves/cots	Packing Lines A and B	Dip tank	0.238	9.9	0.084	0.00852
	16	gloves/cots	Packing Lines A and B	Dip tank	0.238	10.0	0.249	0.0251
						Facility 3 Geometric Mean	0.156	0.0159
						Facility 3 Arithmetic Mean	0.166	0.0169
						Facility 3 Standard Deviation	0.062	0.0062
Citrus Packers								
4	17	none	Packing Line - hand pack	Foam	0.543	8.2	0.692	0.085
	18	none	Packing Line - hand pack	Foam	0.543	6.6	0.504	0.076
	19	none	Packing Line - hand pack	Foam	0.543	8.2	2.568	0.312
	20	none	Packing Line - hand pack	Foam	0.543	7.8	0.371	0.048
	21	none	Packing Line - hand pack	Foam	0.543	7.5	0.927	0.124
						Facility 4 Geometric Mean	0.790	0.104
						Facility 4 Arithmetic Mean	1.012	0.129

Table 11. Potential Hand Exposure for Pear and Citrus Packers (mg/workday and mg/hr)

Facility No.	Worker No.	Hand protection	Work Location	Treatment type	Average OPP treatment concentration	Workday Duration (hr)	Total Potential Hand Exposure[b] (mg/workday)	Total Potential Hand Exposure[b] (mg/hr)
					Facility 4 Standard Deviation		0.894	0.106
5	22	none	Hand Pack Area	Spray	0.776	9.4	0.082	0.00872
	23	none	Hand Pack Area	Spray	0.776	7.9	0.067	0.00851
	24	none	Hand Pack Area	Spray	0.776	8.4	0.204	0.024
	25	none	Hand Pack Area	Spray	0.776	9.6	0.208	0.022
	26	none	Hand Pack Area	Spray	0.776	8.5	0.236	0.028
					Facility 5 Geometric Mean		0.140	0.016
					Facility 5 Arithmetic Mean		0.159	0.018
					Facility 5 Standard Deviation		0.078	0.009
6	27	gloves at times	Machine Pack Area	Spray	1.29	8.2	1.012	0.123
	28	gloves at times	Machine Pack Area	Spray	1.29	7.7	0.304	0.040
	29	gloves at times	Machine Pack Area	Spray	1.29	8.1	0.151	0.019
	30	gloves at times	Machine Pack Area	Spray	1.29	8.1	0.116	0.014
	31	gloves at times	Machine Pack Area	Spray	1.29	7.5	0.084	0.011
					Facility 6 Geometric Mean		0.214	0.0271
					Facility 6 Arithmetic Mean		0.333	0.0415
					Facility 6 St Dev		0.389	0.0471

a. Workday duration is based on the monitoring duration, which was recorded for inhalation monitoring purposes.
b. Total potential hand residues represent 3 to 6 hand wash samples.
½ LOD was used if residues were reported as <LOD.

605	0.605	62.147	0.062
989	0.989	101.610	0.102
777	0.777	79.567	0.080
844.7	*0.84*	*87.2*	*0.087*
861.6	*0.86*	*88.9*	*0.089*
185.7	*0.19*	*18.9*	*0.019*

Table 12. Potential Hand Exposure for Pear and Citrus Sorters (mg/workday and mg/hr)

Facility No.	Worker No.	Hand protection	Work Location	Treatment type	Average OPP treatment concentration	Workday's Duration (hr)	Total Potential Hand Exposure[a] (mg/workday)	Total Potential Hand Exposure[a] (mg/hr)
Pear Sorters								
1	1	None	Line 2 sort	Dip tank	0.207	10.2	2.113	0.208
1	2	None	Line 2 sort area	Dip tank	0.207	10.1	3.235	0.322
1	3	None	Line 1 sort	Dip tank	0.14	10.0	2.219	0.221
1	4	None	Line 1 sort	Dip tank	0.14	10.1	1.144	0.114
1	5	None	Line 2 sort	Dip tank	0.207	10.0	2.411	0.242
						Facility 1 Geometric Mean	2.11	0.210
						Facility 1 Arithmetic Mean	2.22	0.221
						Facility 1 Standard Deviation	0.75	0.0746
2	6	None	In sort room	Dip tank	0.23	9.3	No sample	No sample
2	7	None	In sort room	Dip tank	0.23	9.4	2.915	0.309
2	8	None	In sort room	Dip tank	0.23	9.4	2.545	0.270
2	9	None	In sort room	Dip tank	0.23	9.4	3.049	0.326
2	10	None	In sort room	Dip tank	0.23	9.3	1.368	0.147
2	11	None	In sort room	Dip tank	0.23	9.4	1.863	0.197
						Facility 2 Geometric Mean	2.25	0.24
						Facility 2 Arithmetic Mean	2.35	0.25
						Facility 2 Standard Deviation	0.72	0.08
3	12	None	Both sort lines	Dip tank	0.238	9.4	0.855	0.091
3	13	band aid on thumb	Line a sorting	Dip tank	0.238	9.8	1.082	0.110
3	14	tape on end of fingers	Line b sorting	Dip tank	0.238	9.7	0.605	0.062
3	15	tape on end of fingers	Both sort lines	Dip tank	0.238	9.7	0.989	0.102
3	16	None	Line b sorting	Dip tank	0.238	9.8	0.777	0.080
						Facility 3 Geometric Mean	0.84	0.087
						Facility 3 Arithmetic Mean	0.86	0.089
						Facility 3 Standard Deviation	0.19	0.019
Citrus Sorters								
4	17	None	Main sort area	Foam	0.543	8.3	0.759	0.092
4	18	None	Pre-sort area (large open)	Foam	0.543	8.6	1.045	0.122
4	19	None	Pre-sort area (large open)	Foam	0.543	8.5	3.881	0.457
4	20	None	Main sort area	Foam	0.543	8.6	0.897	0.104
4	21	None	Main sort area	Foam	0.543	8.5	2.546	0.301
						Facility 4 Geometric Mean	1.48	0.174
						Facility 4 Arithmetic Mean	1.83	0.215
						Facility 4 Standard Deviation	1.36	0.160

Table 12. Potential Hand Exposure for Pear and Citrus Sorters (mg/workday and mg/hr)

Facility No.	Worker No.	Hand protection	Work Location	Treatment type	Average OPP treatment concentration	Workday Duration (hr)	Total Potential Hand Exposure (mg/workday)[b]	Total Potential Hand Exposure (mg/hr)
5	22	None	Tented pre-sort (small)	Spray	0.776	9.8	1.413	0.144
5	23	None	Main sort area	Spray	0.776	9.7	0.197	0.020
5	24	None	Tented pre-sort (small)	Spray	0.776	9.6	0.725	0.075
5	25	None	Main sort area	Spray	0.776	9.8	0.188	0.019
5	26	None	Main sort area	Spray	0.776	9.8	0.469	0.048
						Facility 5 Geometric Mean	0.447	0.046
						Facility 5 Arithmetic Mean	0.598	0.061
						Facility 5 Standard Deviation	0.507	0.052
6	27	tape on end of fingers	Main sort area	Spray	1.29	8.2	1.848	0.224
6	28	tape on end of fingers	Tented pre-sort (small)	Spray	1.29	7.8	2.524	0.323
6	29	tape on end of fingers	Tented pre-sort (small)	Spray	1.29	8.2	1.621	0.199
6	30	tape on end of fingers	Main sort area	Spray	1.29	8.1	3.670	0.452
6	31	tape on end of fingers	Main sort area	Spray	1.29	7.9	1.487	0.188
						Facility 6 Geometric Mean	2.10	0.262
						Facility 6 Arithmetic Mean	2.23	0.277
						Facility 6 Standard Deviation	0.90	0.111

a. Workday duration is based on the monitoring duration, which was recorded for inhalation monitoring purposes.
b. Total potential hand residues represent 3 to 7 hand wash samples.
½ LOD was used if residues were reported as <LOD.

855	0.855	90.957	0.091
1082	1.082	110.408	0.110
8956	8.956	920.168	0.920
989	0.989	101.610	0.102
777	0.777	79.567	0.080
1448.1	*1.45*	*149.5*	*0.150*
2531.9	*2.53*	*260.5*	*0.261*
3593.3	*3.59*	*368.9*	*0.369*

Table 13 Potential Inhalation Exposure for Pear and Citrus Packers

Facility No.	Worker No.	Work Location	Treatment type	Ventilation	Avg. OPP treatment concentration	Time (hrs)	Vol. (L)	Avg. Flow Rate (L/min)	OPP Residue (μg)	Conc.[a] ($\mu g/m^3$)	NAFTA Breathing Rate (L/min)	Inhalation Exposure	
												mg[b] per workday	mg/hr[c]
Pear Packers													
1	1	Packing Line 1	Dip tank	Passive ventilation A fraction of re-circulated air from dryer was vented out of facility	1.4	8.8	526	1.00	33.3	63.3	16.7	0.558	0.0634
1	2	Packing Line 1	Dip tank		1.4	10.1	618	1.02	39	63.1	16.7	0.638	0.0632
1	3	Packing Line 2	Dip tank		0.207	10.2	612	1.00	49.2	80.4	16.7	0.820	0.0806
1	4	Packing Line 2	Dip tank		0.207	10.2	641	1.05	52.7	82.2	16.7	0.838	0.0824
1	5	Packing Line 2	Dip tank		0.207	10.0	615	1.02	53.3	86.7	16.7	0.871	0.0868
											Facility 1 Geometric Mean	0.734	0.0746
											Facility 1 Arithmetic Mean	0.745	0.0753
											Facility 1 Standard Deviation	0.138	0.0111
2	6	Packing Line	Dip tank	Passive ventilation. Local cooling fans present though not used.	0.23	9.6	607	1.05	48.7	80.2	16.7	0.774	0.0804
2	7	Packing Line	Dip tank		0.23	9.5	606	1.06	58.4	96.4	16.7	0.921	0.0966
2	8	Packing Line	Dip tank		0.23	9.6	606	1.05	48.9	80.7	16.7	0.778	0.0809
2	9	Packing Line	Dip tank		0.23	9.3	587	1.05	55.1	93.9	16.7	0.876	0.0941
2	10	Packing Line	Dip tank		0.23	9.4	575	1.02	43.8	76.2	16.7	0.716	0.0763
2	11	Packing Line	Dip tank		0.23	9.2	566	1.02	45.8	80.9	16.7	0.747	0.0811
											Facility 2 Geometric Mean	0.799	0.085
											Facility 2 Arithmetic Mean	0.802	0.085
											Facility 2 Standard Deviation	0.079	0.008
3	12	Packing Lines A and B	Dip tank	Passive ventilation. Ceiling had open vents. Dryer recirculated all ai, no air vented.	0.238	9.8	640	1.09	36.7	57.3	16.7	0.6	0.0575
3	13	Packing Lines A and B	Dip tank		0.238	9.8	666	1.13	59	88.6	16.7	0.9	0.0888
3	14	Packing Lines A and B	Dip tank		0.238	9.8	655	1.11	25.5	38.9	16.7	0.4	0.0390
3	15	Packing Lines A and B	Dip tank		0.238	9.9	652	1.10	38	58.3	16.7	0.6	0.0584
3	16	Packing Lines A and B	Dip tank		0.238	10.0	645	1.08	57	88.4	16.7	0.9	0.0885
											Facility 3 Geometric Mean	0.625	0.063
											Facility 3 Arithmetic Mean	0.655	0.066
											Facility 3 Standard Deviation	0.216	0.022
Citrus Packers													
4	17	Packing Line - hand pack	Foam	ceiling fans, passive, dryer vent	0.543	8.2	489	1.00	2.05	4.12	16.7	0.0342	0.0042
4	18	Packing Line - hand pack	Foam		0.543	6.6	401	1.01	1.37	3.42	16.7	0.0227	0.0034
4	19	Packing Line - hand pack	Foam		0.543	8.2	512	1.04	2.73	5.33	16.7	0.0439	0.0053
4	20	Packing Line - hand pack	Foam		0.543	7.8	467	1.00	2	4.28	16.7	0.0334	0.0043

Table 13 Potential Inhalation Exposure for Pear and Citrus Packers

Facility No.	Worker No.	Work Location	Treatment type	Ventilation	Avg. OPP treatment concentration	Time (hrs)	Vol. (L)	Avg. Flow Rate (L/min)	OPP Residue (μg)	Conc.[a] (μg/m³)	NAFTA Breathing Rate (L/min)	Inhalation Exposure	
												mg[b] per workday	mg/hr[c]
4	21	Packing Line - hand pack	Foam		0.543	7.5	448	1.00	2.3	5.13	16.7	0.0384	0.0051
											Facility 4 Geometric Mean	0.0337	0.00442
											Facility 4 Arithmetic Mean	0.0345	0.00448
											Facility 4 Standard Deviation	0.0078	0.00078
5	22	Hand Pack Area	Spray	ceiling fans, passive, dryer vent	0.776	9.4	559	0.99	0.415	0.742	16.7	0.0070	0.0007
5	23	Hand Pack Area	Spray		0.776	7.9	472	1.00	0.487	1.03	16.7	0.0081	0.0010
5	24	Hand Pack Area	Spray		0.776	8.4	495	0.98	0.54	1.09	16.7	0.0092	0.0011
5	25	Hand Pack Area	Spray		0.776	9.6	565	0.98	0.397	0.703	16.7	0.0068	0.0007
5	26	Hand Pack Area	Spray		0.776	8.5	501	0.98	0.495	0.988	0.0167	0.0084	0.0010
											Facility 5 Geometric Mean	0.00785	0.000899
											Facility 5 Arithmetic Mean	0.00791	0.000913
											Facility 5 Standard Deviation	0.00102	0.000177
6	27	Machine Pack Area	Spray	ceiling fans, passive, dryer vent	1.29	8.2	497	1.01	3.26	6.56	16.7	0.0539	0.0066
6	28	Machine Pack Area	Spray		1.29	7.7	442	0.96	6.66	15.1	16.7	0.1158	0.0151
6	29	Machine Pack Area	Spray		1.29	8.1	460	0.95	7.66	16.7	16.7	0.1346	0.0167
6	30	Machine Pack Area	Spray		1.29	8.1	464	0.96	6.37	13.7	16.7	0.1107	0.0138
6	31	Machine Pack Area	Spray		1.29	7.5	434	0.96	4.65	10.7	16.7	0.0809	0.0107
											Facility 6 Geometric Mean	0.0945	0.0120
											Facility 6 Arithmetic	0.0992	0.0126
											Facility 6 Standard Deviation	0.0318	0.0040

[a]Concentration (μg /m³) = (Total Inhalation Residue (μg)) / ((Flow Rate (L/min) * Sampling Time (min)) / 1000 μg/mg)
[b] Potential Inhalation exposure (mg/workday) = (Total inhalation residue (mg) * (Breathing rate (16.7 L/min) / Flow rate (L/min))
[c] Potential Inhalation exposure (mg/hr) = (Total inhalation residue (mg) * (Breathing rate (16.7 L/min) / Flow rate (L/min))/Sample duration (hr)

Table 14. Potential Inhalation Exposure for Pear and Citrus Sorters (mg/workday and mg/hr)

Facility No.	Worker No.	Work Location	Treatment type	Ventilation	Avg. OPP treatment concentration	Time (hrs)	Vol. (L)	Avg. Flow Rate (L/min)	OPP Residue (μg)	Conc.[a] ($\mu g/m^3$)	NAFTA Breathing Rate (L/min)	Inhalation Exposure	
												mg[b] per workday	mg/hr[c]
Pears													
1	1	Line 2 sort	Dip tank		0.207	10.2	621	1.02	68.3	110	0.0167	1.119	0.1102
1	2	Line 2 sort area	Dip tank		0.207	10.1	616	1.02	74	120	0.0167	1.210	0.1204
1	3	Line 1 sort	Dip tank		0.14	10.0	615	1.02	61.3	99.7	0.0167	1.002	0.0999
1	4	Line 1 sort	Dip tank		0.14	10.1	616	1.02	62.6	102	0.0167	1.023	0.1018
1	5	Line 2 sort	Dip tank		0.207	10.0	611	1.02	66.6	109	0.0167	1.089	0.1092
											Facility 1 Geometric Mean	1.09	0.108
											Facility 1 Arithmetic	1.09	0.108
											Facility 1 Standard Deviation	0.0826	0.00811
2	6	In sort room	Dip tank		0.23	9.3	579	1.04	89.1	154	0.0167	1.431	0.1542
2	7	In sort room	Dip tank		0.23	9.4	583	1.03	73.4	126	0.0167	1.190	0.1262
2	8	In sort room	Dip tank		0.23	9.4	588	1.04	69.4	118	0.0167	1.114	0.1183
2	9	In sort room	Dip tank		0.23	9.4	585	1.04	76.8	131	0.0167	1.232	0.1315
2	10	In sort room	Dip tank		0.23	9.3	575	1.03	71.7	125	0.0167	1.162	0.1249
2	11	In sort room	Dip tank		0.23	9.4	583	1.03	72.3	124	0.0167	1.172	0.1243
											Facility 2 Geometric Mean	1.17	0.129
											Facility 2 Arithmetic Mean	1.17	0.130
											Facility 2 Standard Deviation	0.0431	0.0126
3	12	Both sort lines	Dip tank		0.238	9.4	620	1.10	25.5	41.1	0.0167	0.387	0.0412
3	13	Line a sorting	Dip tank		0.238	9.8	659	1.12	33.9	51.4	0.0167	0.505	0.0515
3	14	Line b sorting	Dip tank		0.238	9.7	607	1.04	30.8	50.7	0.0167	0.495	0.0508
3	15	Both sort lines	Dip tank		0.238	9.7	613	1.05	28.8	47	0.0167	0.458	0.0471
3	16	Line b sorting	Dip tank		0.238	9.8	598	1.02	28.2	47.2	0.0167	0.461	0.0473
											Facility 3 Geometric Mean	0.459	0.0474
											Facility 3 Arithmetic Mean	0.461	0.0476
											Facility 3 Standard Deviation	0.0462	0.00410
						Citrus							
4	17	Main sort area	Foam	ceiling fans, passive, dryer vent	0.543	8.3	490	0.99	14.3	29.2	0.0167	0.241	0.0292
4	18	Pre-sort area	Foam		0.543	8.6	535	1.04	19.6	36.6	0.0167	0.314	0.0367
4	19	Pre-sort area	Foam		0.543	8.5	510	1.00	25	49	0.0167	0.418	0.0491
4	20	Main sort area	Foam		0.543	8.6	516	1.00	7.97	15.4	0.0167	0.133	0.0155
4	21	Main sort area	Foam		0.543	8.5	502	0.99	6.87	13.7	0.0167	0.116	0.0137
											Facility 4 Geometric Mean	0.218	0.0257
											Facility 4 Arithmetic Mean	0.244	0.0289
											Facility 4 Standard Deviation	0.126	0.0148
5	22	Tented pre-sort	Spray	ceiling fans, passive, dryer vent	0.776	9.8	582	0.99	17	29.2	0.0167	0.287	0.0293
5	23	Main sort area	Spray		0.776	9.7	564	0.97	0.408	0.723	0.0167	0.0070	0.0007
5	24	Tented pre-sort	Spray		0.776	9.6	571	0.99	13.5	23.6	0.0167	0.228	0.0237

Table 14. Potential Inhalation Exposure for Pear and Citrus Sorters (mg/workday and mg/hr)

Facility No.	Worker No.	Work Location	Treatment type	Ventilation	Avg. OPP treatment concentration	Time (hrs)	Vol. (L)	Avg. Flow Rate (L/min)	OPP Residue (μg)	Conc.[a] (μg/m^3)	NAFTA Breathing Rate (L/min)	Inhalation Exposure	
												mg[b] per workday	mg/hr[c]
5	25	Main sort area	Spray		0.776	9.8	564	0.96	0.48	0.851	0.0167	0.0083	0.0009
5	26	Main sort area	Spray		0.776	9.8	581	0.99	0.556	0.957	0.0167	0.0094	0.0010
											Facility 5 Geometric Mean	0.0324	0.00333
											Facility 5 Arithmetic Mean	0.108	0.0111
											Facility 5 Standard Deviation	0.138	0.0142
6	27	Main sort area	Spray	ceiling fans, passive, dryer vent	1.29	8.2	484	0.98	58.7	121	0.0167	1.001	0.1215
6	28	Tented pre-sort	Spray		1.29	7.8	435	0.93	85.6	197	0.0167	1.541	0.1972
6	29	Tented pre-sort	Spray		1.29	8.2	479	0.98	3.2	6.68	0.0167	0.055	0.0067
6	30	Main sort area	Spray		1.29	8.1	463	0.95	4.04	8.73	0.0167	0.071	0.0087
6	31	Main sort area	Spray		1.29	7.9	456	0.96	12.5	27.4	0.0167	0.217	0.0275
											Facility 6 Geometric Mean	0.265	0.033
											Facility 6 Arithmetic Mean	0.577	0.0723
											Facility 6 Standard Deviation	0.665	0.0842

[a]Concentration (μg /m^3) = (Total Inhalation Residue (μg)) / ((Flow Rate (L/min) * Sampling Time (min)) / 1000 l/m^3)

[b] Potential Inhalation exposure (mg/workday) = (Total inhalation residue (mg) * (Breathing rate (16.7 L/min) / Flow rate (L/min))

[c] Potential Inhalation exposure (mg/hr) = (Total inhalation residue (mg) * (Breathing rate (16.7 L/min) / Flow rate (L/min))/Sample duration (hr)

Table 15. Ambient Air Monitoring Results at Citrus Facilities

Area/Location	Height of Samples	Sampling Time (min)	Volume (L)	Flow Rate (L/min)	OPP Residue (μg)	Concentration ($\mu g/m^3$)[a]
Facility 4						
East side of packing line, behind last packer	Breathing	345	345	1.00	2.19	6.348
End of dryer unit, start of main sort area	Breathing	341	331	0.97	11.5	34.743
West end of packing line	6 ft	345	335	0.97	3.06	9.134
Next to sort in pre-sort area, 3 feet above fruit	Breathing	346	346	1.00	17.3	50.000
West end of packing line	6 ft	150	144	0.96	0.988	6.861
East side of packing line, behind last packer	Breathing	151	154	1.02	1.88	12.208
Next to sorter in pre-sort area, 3 ft above fruit	Breathing	150	153	1.02	5.97	39.020
End of dryer unit, start of main sort area	Breathing	148	142	0.96	3.27	23.028
Facility 5						
Hand packaging area in middle of packing area	Breathing	487	482	0.99	0.125	0.259
North side of main sorting table area	Breathing	493	483	0.98	0.358	0.743
Inside tent of pre-sort area next to pre-sorters	Breathing	273	270	0.99	5.800	21.524
Second pre-sort area (untented) on second level	Breathing	482	468	0.97	0.639	1.368
Inside tented pre-sort area next to pre-sorters	Breathing	226	221	0.98	7.430	33.687
Facility 6						
Packaging area next to hand packers	Breathing	431	405	0.94	6.41	15.827
In packing area adjacent to packing machine	Breathing	428	411	0.96	6.14	14.939
Inside tented pre-sort area	Breathing	426	413	0.97	41.1	99.516
Sort platform next to control panel and adjacent sorters	Breathing	427	418	0.98	14.2	33.971
Pre-sort area outside of tented pre-sort station	Breathing	423	398	0.94	114	286.432

[a]Concentration ($\mu g/m^3$) = (OPP Residue (μg)) / ((Flow Rate (L/min) * Sampling Time (min)) * 1000 L/m^3)

Name:
Evaluator
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Date

APPENDIX A

Compliance Checklist for

"Evaluation of Post-Application Exposures to Sodium O-phenylphenate Tetrahydrate/O-phenylphenol to Workers during Post-Harvest Activities at Pear and Citrus Fruit Packaging Facilities."

Compliance Checklist

Compliance with OPPTS Series 875, Occupational and Residential Exposure Test Guidelines, Group B: Guidelines, 875.1200 (indoor dermal) and 875.1400 (indoor inhalation) is critical. The itemized checklist below describes compliance with the major technical aspects of OPPTS 875.1200 and 875.1400.

OPPTS 875.1200

1. *The test substance should be a typical end use product of the active ingredient.* This criterion was met.

2. *Expected deviations from GLPs should be presented concurrently with any protocol deviations and their potential study impacts.* This criterion was partially met. GLP deviations were provided but protocol deviations were not expected.

3. *The application rate used in the study should be provided and should be the maximum rate specified on the label. However, monitoring following application at a typical application rate may be more appropriate in certain cases.* It is unknown if this criterion was met. The test substances used were not identified and product labels were not provided in the Study Report.

4. *Selected sites and indoor conditions of monitoring should be appropriate to the activity.* This criterion appears to have been met. According to the Study Report, the facilities monitored were representative of typical pear and citrus packaging facilities. However, the treatment method of the fruit, building conditions, and the processing/packaging method was slightly different at each facility.

5. *A sufficient number of replicates should be generated to address the exposure issues associated with the population of interest. For indoor exposure monitoring, each study should include a minimum of 15 individuals (replicates) per activity.* This criterion was partially met. A minimum of 15 replicates were conducted for each worker type (5 workers and 5 packers at 3 pear facilities and 3 citrus facilities). However, each site was monitored under slightly different conditions. Differences existed in treatment method of the fruit, building conditions, and processing/packaging method.

6. *The quantity of active ingredient handled and the duration of the monitoring period should be reported for each replicate.* This criterion was only partially met. The Study Report provided the duration of the monitoring period and the concentration of the treatment solution. Versar was not able to determine the quantity of active ingredient handled because the Study Report did not provide the quantity of fruit handled by each worker, or the amount of active ingredient applied to the fruit.

7. *Test subjects should be regular workers, volunteers trained in the work activities required, or typical homeowners.* This criterion was met. All test subjects were regular workers at the facilities being monitored.

8. *Any protective clothing worn by the test subjects should be identified and should be consistent with the product label.* This criterion was partially met. According the Study Report, the product labels do not require the use of personal protective equipment, however, some of the workers wore previously worn thin unwashed cotton gloves or tape on the tips of the fingers to protect the hands and fruit from physical harms. Additionally, the pear packers were finger cots to enable handling of pear paper.

9. *The monitored activity should be representative of a typical working day for the specific task in order to capture all related exposure activities.* This criterion was met.

10. *Dermal exposure pads used for estimating dermal exposure to sprays should be constructed from paper-making pulp or similar material (i.e., alpha-cellulose), approximately 1 mm thick, that will absorb a considerable amount of spray without disintegrating. The alpha-cellulose material should not typically require preextraction to remove substances that interfere with residue analysis. This should be determined prior to using the pads in exposure tests.* This criterion is not applicable. Dermal exposures were monitored using

upper body dosimeters and hand washes.

11. *Dermal exposure pads used for estimating dermal exposure to dust formulations, dried residues, and to dust from granular formulation should be constructed from layers of surgical gauze. The pad should be bound so that an area of gauze at least 2.5 inch square is left exposed. The gauze must be checked for material that would interfere with analysis and be preextracted if necessary.* This criterion is not applicable. Dermal exposures were monitored using upper body dosimeters and hand washes.

12. *A complete set of pads for each exposure period should consist of 10 to 12 pads. If the determination of actual penetration of work clothing is desired in the field study, additional pads can be attached under the worker's outer garments. Pads should be attached under both upper and lower outer garments, particularly in regions expected to receive maximum exposure. Pads under clothing should be near, but not covered by, pads on the outside of the clothing.* This criterion is not applicable. Dermal exposures were monitored using upper body dosimeters and hand washes.

13. *If exposed pads are to be stored prior to extraction, storage envelopes made from heavy filter paper may be used. The envelope must be checked for material that will interfere with analysis. Unwaxed sandwich bags should be used to contain the filter paper envelopes to help protect against contamination.* This criterion is not applicable. Dermal exposures were monitored using upper body dosimeters and hand washes.

14. *Hand rinses should be performed during preliminary studies to ensure that interferences are not present. Plastic bags designed to contain 0.5 gal and strong enough to withstand vigorous shaking (i.e., at least 1 mil inch thickness) should be used. During preliminary studies, plastic bags must be shaken with the solvent to be used in the study to ensure that material which may interfere with analysis is not present.* It is not certain if this criterion was met. Preliminary hand studies were not mentioned in the Study Report.

15. *The analytical procedure must be capable of quantitative detection of residues on exposure pads at a level of 1 ug/cm^2 (or less, if the dermal toxicity of the material under study warrants greater sensitivity).* This criterion was met.

16. *The extraction efficiency of laboratory fortified controls is considered acceptable if the lower limit of the 95% confidence interval is greater than 75%, unless otherwise specified by the Agency. At a minimum, seven determinations should be made at each fortification level to calculate the mean and standard deviation for recovery. Total recovery from field-fortified samples must be greater than 50% for the study.* These criteria were partially met. Field fortification recoveries were greater than 50%. It is unknown how many determinations were made at each fortification level for laboratory fortification samples. However, for field fortification samples, only 2 determinations were made each fortification level.

17. *If the stability of the material of interest is unknown, or if the material is subject to degradation, the investigator must undertake and document a study to ascertain loss of residues while the pads are worn. It is recommended that collection devices be fortified with the same levels expected to occur during the field studies. The dosimeters should be exposed to similar indoor conditions and for the same time period as those expected during field studies.* These criteria were met.

18. *Data should be corrected if any appropriate field fortified, laboratory fortified or storage stability recovery is less than 90 percent.* This criterion was partially met. The Study Author corrected all data if recovery was less than 100%.

19. *Field data should be documented, including chemical information, area description, environmental conditions, application data, equipment information, information on work activity monitored, sample numbers, exposure time, and any other observations.* This criterion was partially met. The exact test substance used as each facility was not provided.

20. *A sample history sheet must be prepared by the laboratory upon receipt of samples.* It is unknown if this criterion was met.

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1. *Expected deviations from GLPs should be presented concurrently with any protocol deviations and their potential study impacts.* This criterion was partially met. GLP deviations were provided but protocol deviations were not provided.

2. *Investigators should submit protocols for review purposes prior to the inception of the study.* It is unknown if the criterion was met. The protocol does not appear to have been approved by EPA.

3. *The test substance should be a typical end use product of the active ingredient.* This criterion was met.

4. *The application rate used in the study should be provided and should be the maximum rate specified on the label. However, monitoring following application at a typical application rate may be more appropriate in certain cases.* It is unknown if this criterion was met. The test substances used were not identified and product labels were not provided in the Study Report.

5. *Selected sites and indoor conditions of monitoring should be appropriate to the activity.* According to the Study Report, the facilities monitored were representative of typical pear and citrus packaging facilities. However, the treatment method of the fruit, building conditions, and the processing/packaging method was slightly different at each facility.

6. *A sufficient number of replicates should be generated to address the exposure issues associated with the population of interest. For indoor exposure monitoring, each study should include a minimum of 15 individuals (replicates) per activity.* This criterion was partially met. A minimum of 15 replicates were conducted for each worker type (5 workers and 5 packers at 3 pear facilities and 3 citrus facilities). However, each site was monitored under slightly different conditions. Differences existed in concentration of test substance applied, treatment method of the fruit, building conditions, gloved or non-gloved hands, and processing/packaging method.

7. *The quantity of active ingredient handled and the duration of the monitoring period should be reported for each replicate.* This criterion was partially met. The Study Report provided the duration of the monitoring period and the concentration of the treatment solution applied to the fruit. The Study Report did not provide the quantity of fruit handled for each worker.

8. *Test subjects should be regular workers, volunteers trained in the work activities required, or typical homeowners.* This criterion was met. All test subjects were regular workers at the facilities being monitored.

9. *The monitored activity should be representative of a typical working day for the specific task in order to capture all related exposure activities.* This criterion was met.

10. *When both dermal and inhalation monitoring are required, field studies designed to measure exposure by both routes on the same subjects may be used.* This criterion was met.

11. *The analytical procedure must be capable of measuring exposure to 1 ug/hr (or less, if the toxicity of the material under study warrants greater sensitivity).* This criterion was met.

12. A *trapping efficiency test for the monitoring media chosen must be documented.* This criterion was met.

13. *Air samples should also be tested for breakthrough to ensure that collected material is not lost from the medium during sampling. It is recommended that at least one test be carried out where the initial trap contains 10X the highest amount of residue expected in the field.* This criterion was met. When migration of SOPP from filter to front tube and back was examined, the data show that SOPP remained on the filter under some of the test conditions. Migration to the front tube was seen with high mass loads and sir volumes with either 30 or 80% relative humidity, while breakthrough t the back section of the silica gel tube was essentially nonexistent.

14. The *extraction efficiency of laboratory fortified controls is considered acceptable if the lower limit of the 95% confidence interval is greater than 75%, unless otherwise specified by the Agency. At a minimum, seven determinations should be made at each fortification level to calculate the mean and standard deviation for recovery. Total recovery from field-fortified samples must be greater than 50% for the study.* These criteria were partially met. Field fortification recoveries were greater than 50%. It is unknown how many determinations were made at each fortification level for laboratory fortification samples. For field fortification samples, 2 determinations were made each fortification level.

15. *If trapping media or extracts from field samples are to be stored after exposure, a stability test of the compound of interest must be documented. Media must be stored under the same conditions as field samples. Storage stability samples should be extracted and analyzed immediately before and at appropriate periods during storage. The time periods for storage should be chosen so that the longest corresponds to the longest projected storage period for field samples.* This criterion was met.

16. *A personal monitoring pump capable of producing airflow of at least 2 L/min. should be used and its batteries should be capable of sustaining maximum airflow for at least 4 hours without recharging. Airflow should be measured at the beginning and end of the exposure period.* This criterion was not met. The airflow rate used was 1 L/min.

17. *Appropriate air sampling media should be selected. The medium should entrap a high percentage of the chemical passing through it, and it should allow the elution of a high percentage of the entrapped chemical for analysis.* This criterion was met.

18. *If exposed media are to be stored prior to extraction, storage envelopes made from heavy filter paper may be used. The envelope must be checked for material that will interfere with analysis. Unwaxed sandwich bags should be used to contain the filter paper envelopes to help protect against contamination.* This criterion is not applicable. Zip lock bags were used to store samples.

19. *Personal monitors should be arranged with the intake tube positioned downward, as near as possible to the nose level of the subject. The height of the intake tube is especially important when taking samples indoors where walls or ceilings are being sprayed.* This criterion was met.

20. *Field calibration of personal monitors should be performed at the beginning and end of the exposure period.* This criterion was met.

21. *Field fortification samples and blanks should be analyzed for correction of residue losses occurring during the exposure period. Fortified samples and blanks should be fortified at the expected residue level of the actual field samples. Fortified blanks should be exposed to the same indoor conditions.* This criterion was met.

22. *Respirator pads should be removed using clean tweezers and placed in protective white crepe filter paper envelopes inside sandwich bags. The pads should be stored in a chest containing ice until they are returned to the laboratory, where they should be stored in a freezer prior to extraction.* This criterion was met.

23. *Field data should be documented, including chemical information, area description, environmental conditions, application data, equipment information, information on work activity monitored, sample numbers, exposure*

time, and any other observations. This criterion was partially met. The exact test substance used as each facility was not provided.

24. *Analysis methods should be documented and appropriate.* This criterion was met.

25. *A sample history sheet must be prepared by the laboratory upon receipt of samples.* It is uncertain if this criterion was met.

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Chemical Name: o-Phenylphenol, sodium salt

PC Code: 064104
HED File Code: 61500 SRRD Risks
Memo Date: 11/16/2005
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Accession #: 000-00-8015

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